U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-285 419

Intercomparison of Samplers Used in the Determination of Aerosol Composition

California Univ, Livermore Lawrence Livermore Lab

Prepared for

Environmental Sciences Research Lab, Research Triangle Park, N C

Jul 78

United States
Environmental Protection
Agency

Environmental Sciences Research
Laboratory
Research Triangle Park NC 27711

EPA-600/7-78-118
July 1978

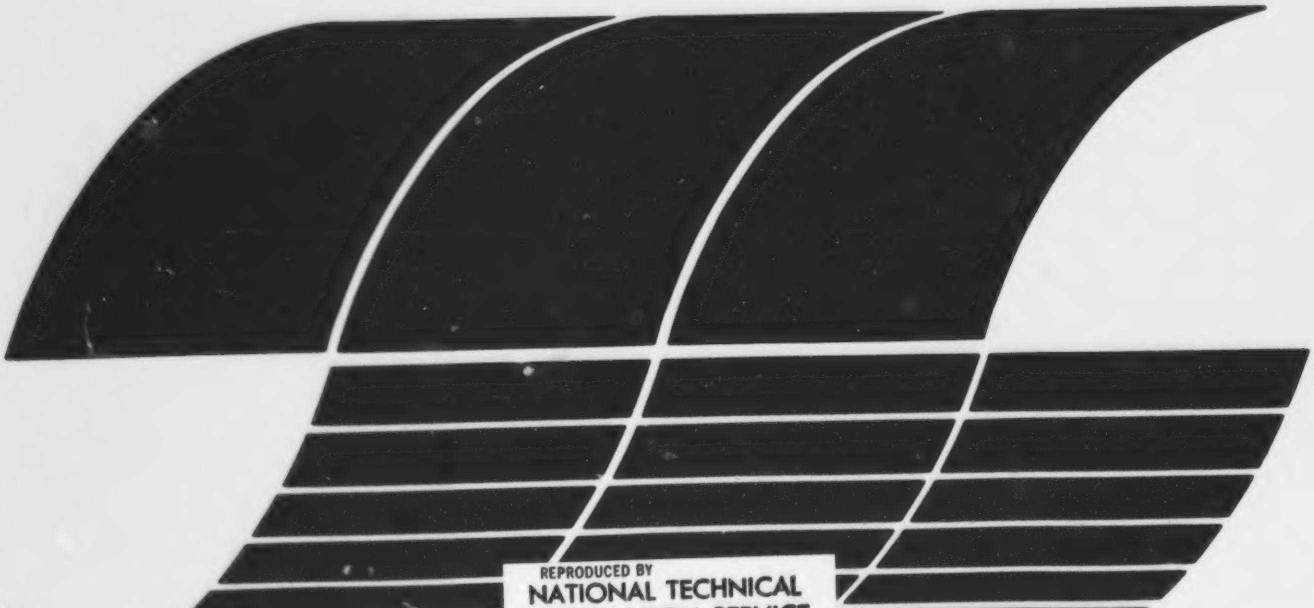
Research and Development

PB 285 419

EPA

Intercomparison of Samplers Used in the Determination of Aerosol Composition

Interagency Energy/Environment R&D Program Report



REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the INTERAGENCY ENERGY-ENVIRONMENT RESEARCH AND DEVELOPMENT series. Reports in this series result from the effort funded under the 17-agency Federal Energy/Environment Research and Development Program. These studies relate to EPA's mission to protect the public health and welfare from adverse effects of pollutants associated with energy systems. The goal of the Program is to assure the rapid development of domestic energy supplies in an environmentally-compatible manner by providing the necessary environmental data and control technology. Investigations include analyses of the transport of energy-related pollutants and their health and ecological effects; assessments of, and development of, control technologies for energy systems; and integrated assessments of a wide range of energy-related environmental issues.

REVIEW NOTICE

This report has been reviewed by the participating Federal Agencies, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/7-78-118

2.

3. RECIPIENT'S ACCESSION NO.
PB285419

4. TITLE AND SUBTITLE
INTERCOMPARISON OF SAMPLERS USED IN THE DETERMINATION OF AEROSOL COMPOSITION

5. REPORT DATE
July 1978

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
D.C. Camp, A.L. Van Lehn, and B.L. Loo

8. PERFORMING ORGANIZATION REPORT N

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Lawrence Livermore Laboratory
Livermore, CA 94550
Lawrence Berkeley Laboratory
Berkeley, CA 94720

10. PROGRAM ELEMENT NO.
1NE625D EB-11 (FY-78)

11. CONTRACT GRANT NO.
IAG-D6-0800
IAG-D7-F1108

12. SPONSORING AGENCY NAME AND ADDRESS
Environmental Sciences Research Laboratory-RTP, NC
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

13. TYPE OF REPORT AND PERIOD COVERE
Final

14. SPONSORING AGENCY CODE
EPA/600/09

15. SUPPLEMENTARY NOTES

16. ABSTRACT

An intercomparison study was carried out to evaluate the performance of 11 different designs of aerosol samplers. The samplers were operated by participating scientific groups having recognized expertise in sampler development and operation. The devices tested include hi-vol, TWO MASS, cyclone, CHAMP, streaker, stacked filter, and manual and automated dichotomous samplers. The samplers were operated in Charlesto WV for eight consecutive days duirng May of 1977. The collection surfaces of each sampler were changed at least every 12 hours which enabled the intercomparison to be made for 16 sampling periods. The collected samples were returned to the laboratory of each participant and analyzed for mass, nitrate, sulfur or sulfate, lead, and 9 other elements. Most of the samplers separated the aerosol into two fractions with 50% separation diameters ranging from 2.4 μm to 4.3 μm. The upper 50% cutoff diamete for the various samplers ranged from 14 μm to about 30 μm. Best agreement among samplers was found for elmeents such as sulfur and lead that occurred primarily in the fine fraction. The amount of total mass collected was strongly influenced by the upper 50% cutoff diameter of each sampler. For stacked filter samplers and the tandem filter samplers, the fine fraction appeared to be enriched with crustal elements such as Si, Ca, and Fe, which suggests that there are particle bounce errors. Of all the samplers tested, the automatic dichotomous sampler showed the greatest precision.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Air pollution *Aerosols *Samplers *Comparison *Mass *Sulfur		13B 07D 14B 07B

18. DISTRIBUTION STATEMENT
RELEASE TO PUBLIC

19. SECURITY CLASS *(This Report)*
UNCLASSIFIED

20. SECURITY CLASS *(This page)*
UNCLASSIFIED

21. NO. OF PAGES
152

22. PRICE
A08- A01

EPA-600/7-78-118
July 1978

INTERCOMPARISON OF SAMPLERS USED IN THE DETERMINATION OF AEROSOL COMPOSITION

by

David C. Camp and Allan L. Van Lehn
Lawrence Livermore Laboratory
Livermore, CA 94550

and

Billy W. Loo
Lawrence Berkeley Laboratory
Berkeley, CA 94720

EPA-IAG-D7-F1108

Project Officer

Thomas G. Dzubay and Robert K. Stevens
Atmospheric Chemistry and Physics Division
Environmental Sciences Research Laboratory
Research Triangle Park, NC 27711

This study was conducted
in cooperation with the
U.S. Department of Energy
Washington, D.C.

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH & DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

ia

DISCLAIMER

This report has been reviewed by the Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

An intercomparison study was carried out to evaluate the performance of 11 different designs of aerosol samplers. The samplers were operated by participating scientific groups having recognized expertise in sampler development, operation, and the subsequent analysis of the samples they collected. The devices tested include hi-vol, TWO MASS, multiday, cyclone, CHAMP, streaker, stacked filter, and manual and automated dichotomous samplers. The samplers were operated simultaneously (on the roof of the Federal Building) in Charleston, West Virginia for eight consecutive days during May of 1977. The collection surfaces of each sampler were changed at least every 12 hours which enabled the intercomparison to be made for 16 sampling periods. Samples collected were analyzed by each participant for one or more of the pollutants for mass, nitrate, sulfur or sulfate, lead, and 8 other trace elements. The analysis methods used by the various participants included x-ray fluorescence, particle induced x-ray emission, atomic absorption, ion chromatography, colorimetry, beta gauge and gravimetric techniques.

Most of the samplers separated the aerosol into two fractions with 50 percent separation diameters ranging from 2.4 µm to 4.3 µm. The upper 50 percent cutoff diameter for the various samplers ranged from 14 µm to above 30 µm. Data were intercompared for the total, fine and coarse size fractions.

Best agreement among samplers was found for elements such as sulfur and lead that occurred primarily in the fine fraction.

The amount of total mass collected appeared to be strongly influenced by the upper 50 percent cutoff diameter of each sampler.

For the stacked filter samplers and the tandem filter samplers, the fine fraction appeared to be enriched with crustal elements such as Si, Ca, and Fe, which suggests that there are particle bounce errors.

Of all the samplers reporting results, the automated dichotomous sampler showed the greatest precision for the fine fraction species.

In the intercomparison study, total sulfur was measured by x-ray fluorescence, and sulfate was measured by ion chromatography and by wet chemical methods. The mean sulfur and sulfate concentrations were in agreement with the assumption that all of the sulfur is in the form of sulfate.

CONTENTS

Abstract iii

Figures vi

Tables vii

Acknowledgements viii

1. Introduction 1
2. Conclusions 9
3. Recommendations 11
4. Field Study Conditions 13
5. Mathematical Treatment of Results 19
6. Selected Results and Discussion 27

References 49

Appendices

A. Sampler and Analytical Technique Summaries 51

B. Outlier and Regression Analysis Equations 94

C. Tabulated Pollutant Results 99

FIGURES

Number Page

1 Photograph of the samplers on the roof of the Federal Building, and a sampler identification chart 6

2 Hourly temperatures recorded at the Charleston Airport during the study 15

3 Hourly relative humidity recorded at the Charleston Airport during the study 15

4 The mean hourly wind direction and velocity recorded atop the Federal Building 17

5 Wind speed and direction at the study shown as wind roses 18

6 A portion of one of the tabular results listed in Appendix C . . . 25

7 Mean mass and selected pollutant concentrations vs period 31

8 Average sampler ratios vs sampler type for selected pollutants . . 37

9 Average sampler ratios for sulfur and sulfate combined 40

10 Average sampler ratios for zinc and copper 45

TABLES

Number Page

1 Intercomparison Study Participants 3

2 Sampler Types Brought to the Study 5

3 Sampler Types, Inlet Heights and Spacings 7

4 Sampler Types vs. Operating Characteristics and Pollutants Reported 8

5 Outliers According to the Dixon Criterion (α = 4%) 22

6 Mean Concentration Changes vs Number of Samplers Averaged 23

7 16-Period Pollutant Concentration Averages from all Samplers Reporting Results for May 11-19, 1977 29

8 Possible South to East Dispersion in the Air Sampled 32

9 Regression Analysis Fits of Referee Analysts Results 33

10 Ratio of XRF Results for Cut to Uncut Filter Samples 34

11 Participant Results from Analytical Technique Quality Control Samples 35

12 Pairwise Intercomparison of Sampler Precisions (%) 39

13 Coarse Particle Bounce into the Fine Fraction 43

14 Percent of Pollutant in the Small or Large Fraction 48

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the essential guidance provided by Mr. William Matthews, West Virginia Federal Buildings Manager. during the planning phase of this study. He was instrumental in seeing that additional electrical power was installed on the roof of the Federal Building in Charleston, WV. The cooperation and assistance rendered by Mr. Howard Stanley, Charleston Federal Building Foreman, and his crew allowed the study to proceed smoothly.

The continued support, creative suggestions, and encouragement offered by the Project Officers, Mr. Robert Stevens and Dr. Tom Dzubay, in the planning phase, during execution, and especially during the preparation of the final report is gratefully acknowledged. They were also helpful in all phases of the November, 1977 Workshop at which preliminary results of this study were presented.

Grateful appreciation is also extended to each of the intercomparison study participants who, through their creative criticisms, helped make this final report more comprehensive and complete.

Finally, it is a pleasure to acknowledge the Staff of the Director's Office Correspondence Center at Lawrence Livermore Laboratory who so cheerfully typed the many drafts and revisions required by a report of this magnitude.

SECTION 1

INTRODUCTION

HISTORICAL PERSPECTIVE

One of the consequences that grew out of the environmental concerns of the 1960's was a demand for better air quality. For research scientists in this field this meant improving the measurement, characterization, and understanding of air pollutants both at their emission sources and in the ambient atmosphere. Consequently, more attention began to be focused on the performance of aerosol particulate samplers. Performance parameters examined more closely included sampler inlet designs, their flow rate capabilities, the particle size cutpoints employed, internal particle loss mechanisms, and types of collection substrates used, to name just a few. As a result of this attention, the development of both simple and sophisticated aerosol particulate samplers began to take place all across the country. Several conferences (1,2) helped focus on what had been accomplished as well as on what the needs were. By 1976 a great deal of air pollution information was being collected with the many different sampler designs, and results were being published in numerous journals. One of the questions that arose following the second conference (2) was how intercomparable are the results from different samplers? If the results did differ, was it by small percentages, by factors of 2, or did they differ by orders of magnitude? Were some pollutants easier to measure than others? Thus, it was suggested that a study be carried out which would begin to answer these and other questions.

OBJECTIVE

The objective of the study was to operate representative state-of-the-art aerosol particulate samplers simultaneously and side-by-side for an extended period and to compare the analytical results. This objective was achieved through a field study at which the samplers were operated by their developers or users in nearly the same manner as they are operated in typical air pollution research and/or monitoring programs. The samples collected were analyzed for selected pollutant concentrations by each participant using those analytical methods normally employed for the type of sample and pollutant collected.

SITE SELECTION

Several considerations entered into the selection of an appropriate site for the field study. Among the more important were that sufficient space, sufficient electrical power, and security for the samplers be provided. It was also desirable to conduct the study in an area where some pollutant information was available. The earlier results would give some indication of the kind of pollutant concentrations to be expected. These considerations led to the selection of the Federal Building in downtown Charleston, West Virginia, as the site where the field study would be conducted.

This is a five story building through which there is access to a large, open roof area. It has the added bonus of a 24-hour security service. The earlier study (3) carried out in the Charleston area indicated that the month of May offered satisfactory weather conditions for the study. The field study was scheduled to begin at 8 am, Wednesday, May 11, 1977, and end at 8 am, Thursday, May 19, 1977. Sample collection was to be continuous throughout the study with collection substrates to be changed at least once every 12 hours. This 8-day duration led to sixteen 12-hour periods for which pollutant concentrations could be intercompared.

POLLUTANTS SPECIES SELECTED

There are a wide range of air pollutant species that could have been measured in such a study. Because the objective of the study was to intercompare results from as many different types of samplers as possible, the number of pollutant species selected was purposefully restricted.

Those pollutant results for which an intercomparison was believed to be meaningful were mass, nitrate, sulfur and sulfate, lead, and eight other trace elements to be selected after the field study was completed. Since the type of samplers brought to the study varied from simple to complex, the study was designed so that comparisons could be made for the total pollutant concentration reported; and also for fine and coarse fractions for samplers which collected particles according to aerodynamic size.

Following completion of the study eight trace elements were chosen. Three of these - silicon, calcium, and titanium - are representative of those elements found in the earth's crust. A fourth element, iron, is also found in this group, but may also be associated with local emission sources. These four elements tend to concentrate in the coarse or large particulate fraction, that is, in particles having aerodynamic sizes greater than 2.0 micrometers. Three other trace elements chosen were copper, zinc, and bromine. The last was chosen because of the well known bromine to lead ratio characteristic of automotive exhausts. The eighth trace element chosen was selenium, which usually occurs in very low concentrations. Its measurement becomes a challenging test of the various samplers and analytical methods used in the study.

PARTICIPANT SELECTION

Because of space restrictions atop the Federal Building in Charleston, only a limited number of samplers could be accommodated. This restriction plus the desirable option of replicate samplers limited the number of participants that could be invited to the study. Table 1 lists those participants invited to the field study and who brought samplers which were representative of those aerosol collection devices most widely used in research and monitoring programs.

TABLE 1. INTERCOMPARISON STUDY PARTICIPANTS

Mr. Robert Burton:	Health Effects Research Laboratory, Environmental Protection Agency, Research Triangle Park, NC 27711
Dr. Thomas Cahill:	Physics Department, University of California, Davis, CA 95616
Dr. R. Delumyea, and Dr. E. Macias:	Department of Chemistry, Washington University, St. Louis, MO 63130
Dr. Thomas Dzubay and R. K. Stevens:	Environmental Sciences Research Laboratory, Environmental Protection Agency, Research Triangle Park, NC 27711
Dr. Martin Hudson:	Physics Department, Florida State University, Tallahassee, FL 32306
Dr. Billy W. Loo:	Lawrence Berkeley Laboratory, Berkeley, CA 94720
Dr. Peter Mueller:	Environmental Research and Technology, Inc., West Lake Village, CA 91361
Dr. Charles Rodes:	Environmental Monitoring & Support Laboratory, Environmental Protection Agency, Research Triangle Park, NC 27711
Dr. Roger Tanner and Dr. Leonard Newman:	Atmospheric Sciences Division, Brookhaven National Laboratory, Upton, L.I., NY 11973

SAMPLER TYPES AND ARRANGEMENT

Table 2 lists those samplers brought to the study. Both a one page summary and detailed description of each type can be found in Appendix A. It is apparent that a number of duplicate samplers were brought. The well known high volume sampler was well represented at the study. Included were those with and without particle size inlet restrictions as used in the CHESS* study carried out in a number of communities by the Environmental Protection Agency (EPA). Of the 35 samplers brought to the study, 20 had the capability of collecting particles in two or more size fractions. Of these 15 reported size fraction results.

All of the samplers assembled on the roof of the Federal Building are shown in Figure 1. This view looks southeast toward downtown Charleston, WV.

---

* Community Health and Environmental Surveillance Studies

The lower part of Fig. 1 includes a sketch of each sampler type. A number is is used to identify each sampler or group of samplers, while a capital letter is attached to only some of the samplers. This letter identification denotes those samplers reporting results which were intercompared and is useful in distinguishing between duplicate or triplicate samplers brought by the same participant. Sampler A is located approximately 9 meters from the eastern corner of the building while sample U is about 9 meters from the southern corner of the Federal Building. All of the samplers were located on a line approximately 1.5 meters from the southeast face of the building. All around the edge of the roof the side of the building continues upward 0.4 meter above the roof level.

Table 3 lists all of the samplers or groups assembled on the roof according to the numerical order shown on the sketch in Fig. 1. The last two columns list the sampler inlet height to the nearest centimeter, and the approximate spacing between sampler inlets. Inlet heights varied from a low of about 0.9 meters to a high of 1.75 meters. (This excludes the SO_2 sampler inlets at 2.4 m. Its results were not part of the intercomparison study).

Table 4 lists the more important operating characteristics for those samplers whose reported results were intercompared. The alphabetical identification of the various samplers is used throughout this report both in the graphical presentations and in the tabular intercomparisons. There are several important points to be noted in this table. First, an examination of the column listing the fine cut points reveals that they vary between 2.5 and 4.3 micrometers. The first two stages of Sampler G, the Sierra Multiday Sampler, were added together before comparing its results with other samplers. Similarly, the column listing the inlet cutoff also shows a range of large particle sizes accepted by each sampler. These variations in cut-point sizes must be kept in mind when examining the results of the fine and coarse particulate fractions. The column listing the frequency of filter changes shows that for some samplers, two to four sub-period totals had to be added together to obtain the desired 12-hour pollutant concentrations. Florida State University employs an analytical technique which is capable of analyzing their linear streaker filters to within ± 30 minutes.

The filter substrates used in the automated dichotomous samplers - C, L, and S - were changed automatically every 6 hours. These samplers also employed a flow control mechanism which shut the samplers down in the event the flow rate dropped below a prescribed tolerance. On several occasions at night the particulate loading was sufficiently heavy to cause shut down very near the end of the first 6 hour period. In these instances the following 6 hours of data were not obtained.

TABLE 2. SAMPLER TYPES BROUGHT TO THE STUDY

Type of Sampler[a]	Participant	Inst.	# Units at study	Results reported for
Diffusion Battery Sampler	Tanner	BNL	1	(b)
High Volume Sampler:	Tanner	BNL	1	1
High Volume Samplers:	Rodes	EPA	2	1[c]
High Volume Sampler:	Burton	EPA	1	1
Champ (with size cuts)	Burton	EPA	2	2
Dichotomous Samplers - ERC.	Rodes	EPA	2	1[c]
Dichotomous Samplers - Manual	Dzubay	EPA	2	2
Dichotomous Samplers - Automated	Loo	LBL	4	3[d]
Linear Streaker	Hudson	FSU	4	2[e]
Batelle Impactors	Hudson	FSU	4	(e)
Tandem Filter Units	Dzubay	EPA	2	2
Stacked Filter Units	Cahill	UCD	2	2[f]
Sierra Multiday	Cahill	UCD	1	1
Cyclone (1 w & 1 w/o size cut)	Mueller	ERT	2	2
Two Mass	Delumyea	WU	4	1
Sulfur dioxide experiment	Loo	LBL	4	(g)

---

a) See Appendix A for a detailed description of each sampler type.
b) Results were reported but were not intercompared, and are not included in the tables of Appendix C.
c) Data were taken with both samplers for only half of the study.
d) The fourth sampler was included in case spare parts were needed for the other three.
e) All four operated throughout the study. Results available from FSU.
f) A third total filter unit was operated throughout the study with no sizing. Only one filter change was made after four days, hence its results could not be intercompared.
g) These samplers were not part of the intercomparision study.

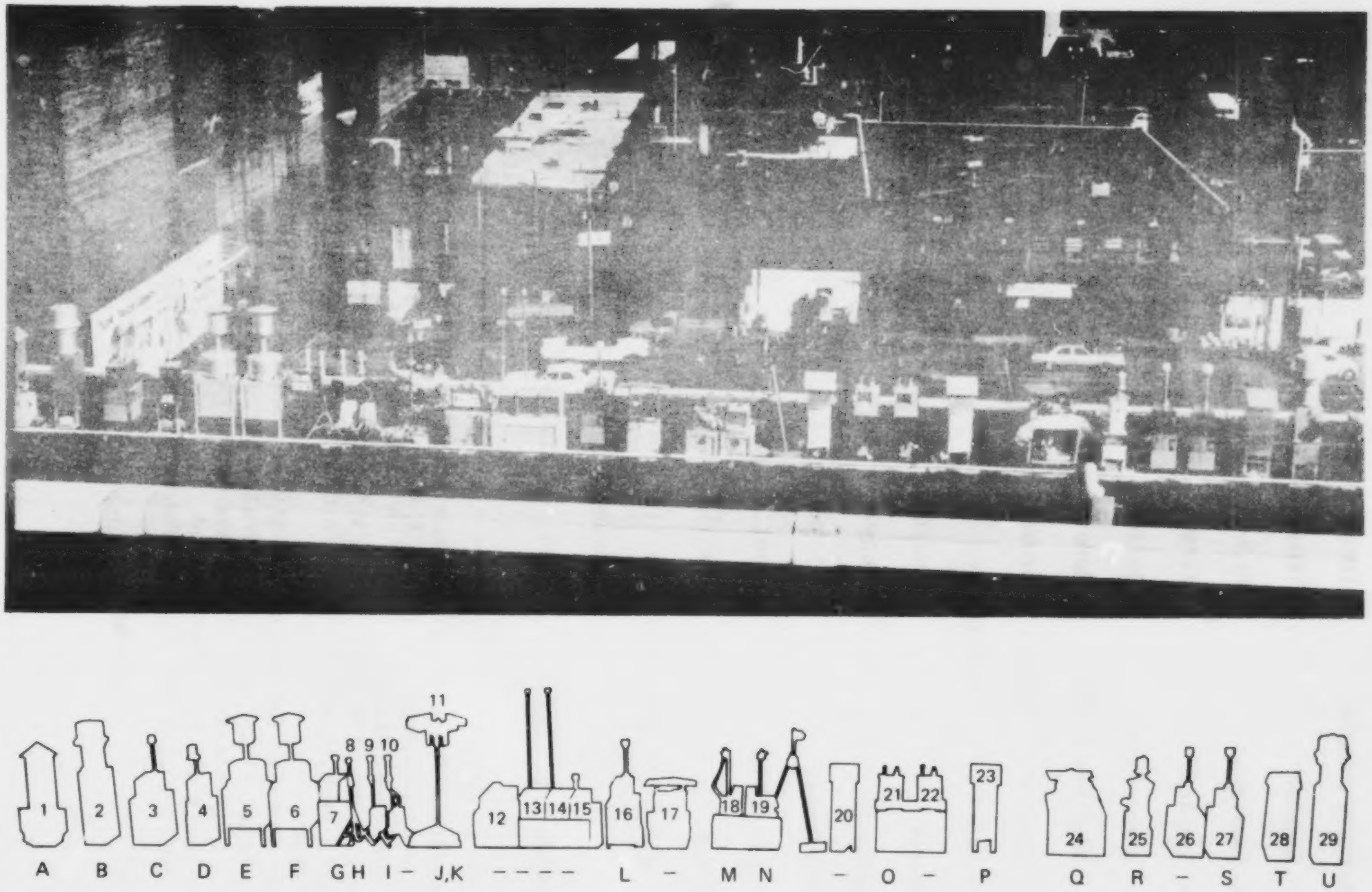

1
2
3
4
5
6
7
8 9 10
11
12
13 14 15
16
17
18 19
20
21 22
23
24
25
26 27
28
29
A B C D E F G H I – J,K – – – – L – M N – O – P Q R – S T U

Figure 1. A photograph of the 39 different samplers assembled on the roof of the Federal Building by 9 invited participants. The profile sketch provides a key to sampler identification. The sampler numbering is from Table 3 and the alphabetical coding from Table 4.

TABLE 3. SAMPLER TYPES, INLET HEIGHTS AND SPACINGS

Sampler Type	Investigator	Inlet Height(cm)	Spacing(cm)
1.[a] Hi-Vol and Diffusion	(Tanner-BNL)	135 & 114	86
2. Champ + Size Fractionator	(Burton-EPA)	160	91
3. Auto Dichotomous	(Loo-LBL)	160	69
4. Manual Dichotomous	(Dzubay-EPA)	132	81
5. Cyclone-total	(Muller-ERT)	175	71
6. Cyclone-fine	(Muller-ERT)	175	71
7. Sierra Multiday	(Cahill-UCD)	140	20
8. Total Filter Unit-1 stage	(Cahill-UCD)	137	30
9. Stacked Filter Unit-2 stages	(Cahill-UCD)	140	28
10. Stacked Filter Unit-3 stages	(Cahill-UCD)	140	~ 81
11. 4-Batelle Impactors 6 stages	(Hudson-FSU)	165	
4-Linear Streakers	(Hudson-FSU)	185	140
12. Sulfur Dioxide Analyzer	(Loo-LBL)	114	~ 0
13. ERC Sampler, w/o MgO	(Loo-LBL)	238	36
14. ERC Sampler, w MgO	(Loo-LBL)	238	36
15. ERC Sampler w/o MgO	(Loo-LBL)	107	76
16. Auto Dichotomous	(Loo-LBL)	160	71
17. 2-Two Mass Samplers	(Delumyea-WU)	89	84
18. Stacked Filter Unit	(Dzubay-EPA)	157	56
19. Stacked Filter Unit	(Dzubay-EPA)	157	124
20. Hi-Vol	(Rodes-EPA)	112	74
21. ERC Virtual Impactor	(Rodes-EPA)	124	56
22. ERC Virtual Impactor	(Rodes-EPA)	124	89
23. Hi-Vol	(Rodes-EPA)	112	132
24. Two Mass + Beta Gauge	(Delumyea-WU)	114	91
25. Manual Dichotomous	(Dzubay-EPA)	132	71
26. Auto Dichotomous	(not working)	157	58
27. Auto Dichotomous	(Loo-LBL)	157	79
28. Hi-Vol	(Burton-EPA)	112	64
29. Champ + Size Fractionator	(Burton-EPA)	157	

[a] These numbers are used in Figure 1 to identify the sampler groups.

TABLE 4. SAMPLER TYPE VS. OPERATING CHARACTERISTICS & POLLUTANTS REPORTED

	Sampler Type	Investigator and Lab	Fine Cut[a] Points µm	Inlet[a] Cutoff µm	Flow[a] Rate (ℓ/m)	Filter[a] Change (hrs)	Pollutants Reported Mass	NO3	SO4	sulfur	Lead	trace[b] elements
A	Hi-Vol	Tanner BNL	-	large	700	12		N	S			
B	Champ + Size Cut	Burton EPA	3.5	∿ 26	1130	12	M	N	S			
C	Auto Dichotomous	Loo LBL	2.4	∿ 25	50	6	M			s	L	te
D	Manual Dichotomous	Dzubay EPA	3.5	14	14	12	M		S	s	L	te
E	ERT - Total	Mueller ERT	-	∿ 15	100	3	M	N	S			
F	ERT - Fine	Mueller ERT	2.5	-	100	3	M	N	S			
G	Sierra Multiday	Cahill UCD	0.78 4.3	< 20	24	12				s	L	te
H	Total Filter 1 stage	Cahill UCD	-	< 20	24	12				s	L	te
I	Stacked Filter 2 stages	Cahill UCD	2.6	< 20	5	12				s	L	te
J	Linear Streaker	Hudson FSU	-	∿ 15	0.35	continuous				s	L	te
K	Linear Streaker	Hudson FSU	-	∿ 15	0.50	continuous				s	L	te
L	Auto Dichotomous	Loo LBL	2.4	∿ 25	50	6	M			s	L	te
M	Tandem Filter	Dzubay EPA	3.5	c)	7.2	12				s	L	te
N	Tanden Filter	Dzubay EPA	3.5	c)	5.9	12				s	L	te
O	ERC Dichotomous	Rodes EPA	3.5	∿ 20	14	12	M		S		L	
P	Hi-Vol	Rodes EPA	-	large	1415	12	M		S			
Q	Two-Mass	Delumyea WU	3.5	c)	16.7	3	M			s		
R	Manual Dichotomous	Dzubay EPA	3.5	14	14	12	M	N	S	s	L	te
S	Auto Dichotomous	Loo EPA	2.4	∿ 25	50	6	M			s	L	te
T	Hi-Vol	Burton EPA	-	large	1130	12	M	N	S			
U	Champ + Size Cut	Burton EPA	3.5	∿ 26	1130	12	M	N	S			

---

a) See Appendix A for a more detailed discussion of these sampler types and their operating characteristics.

b) Trace element means that silicon, calcium, titanium, iron, copper, zinc, bromine, and selenium were usually reported when they could be detected.

c) Not measured

SECTION 2

CONCLUSIONS

An intercomparison study was carried out to evaluate the performance of 11 different designs of aerosol samplers. The devices tested include hi-vol, TWO MASS, cyclone, CHAMP, streaker, stacked filter, and manual and automated dichotomous samplers. The samplers were operated simultaneously on the roof of the Federal Building in Charleston, West Virginia for eight consecutive days during May of 1977. The collection surfaces of each sampler were changed at least every 12 hours which enabled the intercomparison to be made for 16 sampling periods. The collected samples were returned to the laboratory of each participant and analyzed for mass, nitrate, sulfur or sulfate, lead, and 8 other elements.

Most of the samplers separated the aerosol into two fractions with 50 percent separation diameters ranging from 2.4 μm to 4.3 μm. The upper 50 percent cutoff diameter for the various samplers ranged from 14 μm to above 30 μm. Results were intercompared for the total, fine and coarse size fractions. Elements found most abundantly in the fine fraction included S, Zn, Cu, Br, and Pb; elements found most abundantly in the coarse fraction included Si, Ca, Ti, and Fe. The total mass was equally distributed between both size fractions.

Best agreements among samplers was found for elements that occurred primarily in the fine fraction. For lead the standard deviation of the results from all of the samplers were 17% and 11% for the total and fine fractions respectively. The standard deviations for sulfur were 15% and 11% for the total and fine fractions respectively. In computing the standard deviation for sulfur, the results associated with the TWO MASS sampler were excluded. For that sampler the results were lower than the mean by a factor of about 3.

The amount of total mass collected appeared to be strongly influenced by the upper 50 percent cutoff diameter of each sampler. The amounts of Si, Ca, Ti, and Fe collected in the coarse fraction were similarly affected by the inlet. The hi-vol sampler, which had the largest upper cutoff diameter, collected about 50% more mass than the manual dichotomous sampler, which had the lowest upper diameter (14 μm).

For the stacked filter samplers and the tandem filter samplers, the fine fraction was enriched in crustal elements such as Si, Ca, and Fe. This indicates that there are particle bounce errors for such samplers.

Of all the samplers reporting results the automatic dichotomous sampler showed the greatest precision for the fine fraction species. Three automated dichotomous samplers when compared pairwise yielded an average agreement of 1.8%, 1.8% and 3.3% for sulfur, lead, and mass in the fine fraction, respectively. For the total fraction, the agreement between pairs averaged 2%, 3%, 7% and 12% for sulfur, lead, mass and iron, respectively.

In the intercomparison study, total sulfur was measured by x-ray fluorescence, and sulfate was measured by ion chromatography and by wet chemical methods. The mean sulfur and sulfate concentrations were in agreement with the assumption that all of the sulfur is in the form of sulfate. The nitrate results showed the greatest differences among samplers, and no simple explanation for the differences was found.

SECTION 3

RECOMMENDATIONS

This sampler intercomparison study was the first side-by-side field test of a large number of representative state-of-the-art aerosol samplers. It was successful in that it demonstrated for those samplers brought to the study that particulate mass and selected pollutant concentrations can be determined with reasonable accuracy. In fact, for lead, sulfur, and zinc concentrations in the fine fraction, all reported results were within 10% of a mean value. On the other hand nitrate concentrations were not well determined in this study for reasons that remain unclear at this time.

Among those who participated in this study, it was unanimous that the field study was well worthwhile, and it was a general consensous that a similar study should be held again at some future date. With such a future study as a possibility and based on the experiences gained in the present study a number of recommendations can be advanced which may help insure that any future study will be even more successful.

The flow rate of all samples at any future study should be checked periodically (e.g., at least twice a day). More importantly all flow rates ought to be cross-checked with a single flow rate meter so that all sampler flow rates at the study are tied relatively to a single calibration device.

All samplers brought to a future study should have nearly the same inlet restrictions and preferably axially symmetric inlets. Similarly, the cut point used to define the fine particle fraction for all samplers at such a study should be very nearly the same.

Samplers used to evaluate the possibility of any inhomogeneity in the sampled air should be run side-by-side both prior to and following the study for periods approximately 1/4 the duration of the study (i.e., two days before and two days after in an 8-day study).

One or more separate studies should be held soon and devoted to a determination of those factors that influence the determination of nitrate concentrations.

Following completion of the study, analytical technique quality control samples should be mailed to all participants and all participants required to report concentrations in ng/cm^2 for at least three selected pollutants. The method of appealing to independent referee analysts for quality control was successful in this study.

All samplers deployed at any future study should guarantee that they do not exhaust any pollutant which can bias another samplers results. This may require additional filtration of the exhausts of some samplers.

The spacing between samplers at any future study should average 1 meter.

All participants should be required to field and report results for at least duplicate samplers. Also, no samplers should be allowed to take up space or electrical power which do not report results.

As was the case in this study, some form of security is desirable to prevent access to the samplers by the general public.

Multi-redundant fusing of the electrical power was well worth the planning and additional investment required. A number of samplers at this study blew fuses at various times, but none was responsible for the shut down of any other sampler.

Although no rain fell during this study, any future study should plan for this eventuality.

SECTION 4

FIELD STUDY CONDITIONS

AIR HOMOGENITY SAMPLERS AND QUALITY CONTROL SAMPLES

The aerosol samplers were assembled on the roof of the five story Federal Building in Charleston, WV along the southeast face of the building. Since the objective of the field study was to intercompare the pollutant concentrations obtained by samplers that were not located at the same point, it was necessary to test the possibility that the air sampled might not be homogeneous. Interaction between wind and the roof penthouse structures might create non-uniform wind streams. To monitor this possibility, three Lawrence Berkeley Laboratory (LBL) designed automated dichotomous samplers were operated near both ends and near the middle of the linear array of samplers. A detailed discussion of the results is presented in Section 6.

In general duplicate samplers brought by a single participant were not set up side by side. However, an attempt was made to "pair-up" samplers which were similar in operating or design principle. Two samplers might be operated side by side, but were brought to the study by different participants. Some types of samplers were more effectively operated in clusters.

In planning the study it was recognized that the concentrations reported by the various participants would be different. How much of any reported differences are due to sampler performances and how much to the different analytical methods used to analyze the samples, should be resolved if possible. The method chosen to resolve these two for this study was based, in part, on the fact that most of the participants would report trace element concentrations determined from an x-ray emission technique. The method chosen was as follows.

From one of the automated dichotomous samplers operated at the field study, a set of fine particulate fraction samples were selected. This set was analyzed by two referee analysts who were not participants in the study. Both referee analysts used energy dispersive x-ray fluoresence analysis to determine the trace element concentrations in ng/cm^2 of filter area. They sent their results to the study director and from the combined data, concentration values in ng/cm^2 were adopted for each trace element and sample in the set. Then, 3 samples were selected from the set and mailed to each of 8 participants (24 samples-total). X-ray fluorescence analysis carried out before and after extremely vigorous shake tests on the entire set of samples demonstrated that no particle losses would occur as a result of mailing. Each participant then determined selected trace element concentrations in ng/cm^2 for his three samples and reported these results to the study director. Their results were compared with the adopted values from the referee analysts. Agreement between the two would suggest that the analytical method was not a source of any reported pollutant concentration differences. Results for each participants analytical quality control samples can be found in Section 6.

FIELD STUDY PRECAUTIONS AND PROCEDURES

The roof of the Federal Building was of a standard tar and gravel construction. Since the filter substrates used in most of the samplers required changing every 12 hours, a great deal of traffic would occur on this roof surface. To reduce the potential for creating large particles, certain precautions and procedures were adopted. A plywood walkway was laid down on the roof all along and in front (NW) of the samplers. A narrow walkway leading from the roof entrance/exit to the samplers was also laid down. Almost all participant traffic on the roof used these walkways. The roof also contained 3 rest rooms vent stacks and 2 water drains in the vicinity of the samplers. The presence of H_2S gas was clearly noted from these stacks (most serious in the former), hence they were vented away from the immediate sampling area using 6.1 m lengths of flexible plastic pipe. The 3 rest room stacks were vented at the top of the 1st level penthouse (3.35 m) and the water drains were vented at roof level 4 m NW of the sampler array.

Filter substrates were changed at least every 12 hours, at 8 am and 8 pm. Each participant was responsible for the operation of his own sampler, including the changing and storage of new or used filter substrates. At other times traffic on the roof was discouraged. Except for one TV news interview, there was no public traffic on the roof throughout the study. At the end of the study each participant was responsible for the disassembly and removal of his samplers.

Electrical power for all of the samplers was distributed via 12 circuits each with an individual 20 amp circuit breaker. Each of these circuits terminated in a 4-plex electrical outlet into which were plugged one or two individually fused (at 15 amps) 6-circuit multi-outlet modules. Individual sampler power cords were plugged into one of the six circuits which were also separately fused at an appropriate current rating for the particular sampler connected. In the event one sampler drew too much current, this multi-redundant fusing isolated and protected each sampler from all others.

METEOROLOGICAL CONDITIONS

Meteorological conditions were satisfactory during the entire study; however, no rain was recorded during any of the sixteen 12-hour periods. Fig. 2 shows the hourly temperature variations recorded at the Charleston Airport located approximately two miles northeast of the Federal Building. Morning temperatures varied from a low of 3°C (37°F) on the first day of the study to 17°C (63°F) on the last day of the study, while the daytime maximum readings varied from 20°C (68°F) to 31°C (87°F). Since these data were obtained above the valley floor, actual temperatures atop the Federal Building may have been several degrees higher.

The relatively humidity as recorded hourly at the Charleston Airport

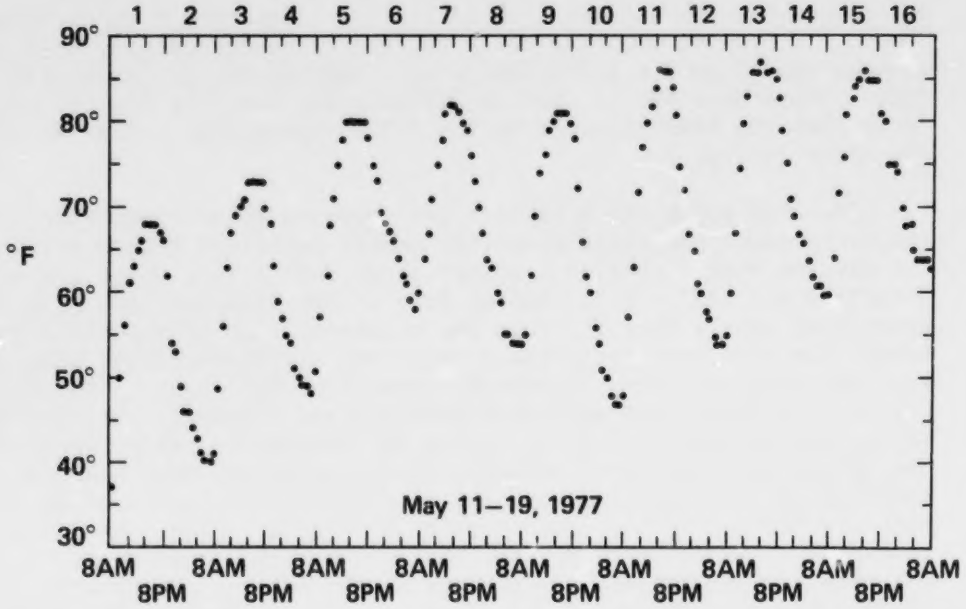


Figure 2. Hourly temperatures recorded at the U.S. Weather Station, Charleston Metropolitan Airport, throughout the intercomparison study.

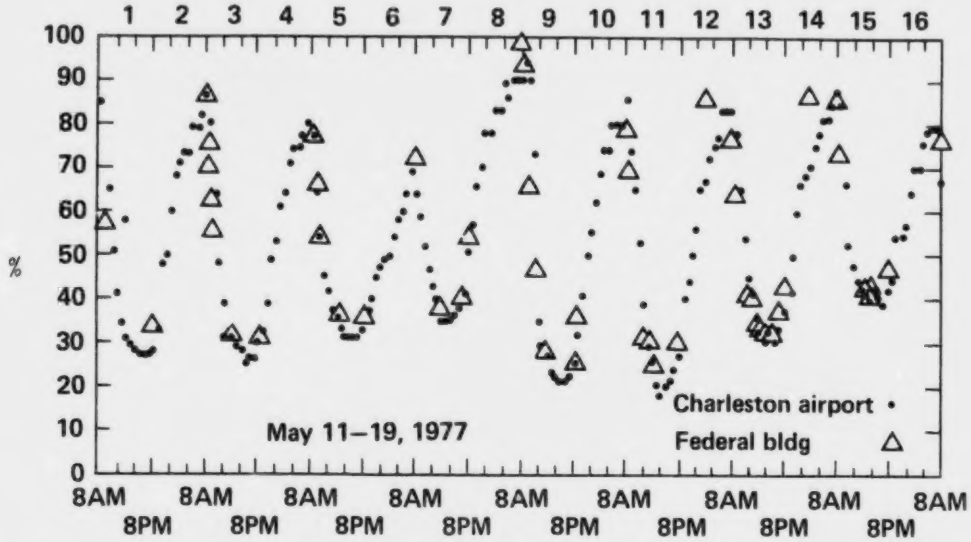


Figure 3. The relative humidity recorded hourly at the U.S. Weather Station, Charleston Airport, and occasionally on the roof of the Federal Building, downtown Charleston.

varied from 18 to 91%, while that recorded intermittently atop the Federal Building showed variations from 24 to 98%. Even though these ranges are different, it appears that the daily cycle of minimum humidity near 4 pm and maximum near 8 am are sufficiently well represented by the hourly Airport data. These data can be used to evaluate any humidity induced chemical effects that may have occurred in the filter substrates. The hourly readings are shown in Fig. 3.

The wind speed and direction (as recorded by an anemometer, wind vane, and strip chart recorders atop the Federal Building) showed a diurnal pattern. The daytime wind direction averaged about 300° ± 45°, while the nightime wind direction was 120° ± 15°. During four of the study periods (2,4,14,16) the winds came nearly directly into the southeast face of the building. After the study, the wind vane strip chart recording was examined and wind directions were analyzed for every 15 minutes throughout the study. From this analysis, hourly directional averages were obtained and plotted. The results are shown in the top section of Fig. 4. Using the anemometer strip chart recording the approximate mean wind velocity sustained during each hour was estimated and also the maximum wind velocity recorded during each hour was noted. These data are plotted in the lower portion of Fig. 4. Wind rose patterns are shown in Fig. 5. The odd periods (daytime) are grouped together at the top, while the even periods (night) are grouped at the bottom. These wind rose data clearly show the diurnal wind pattern typical of the Kanawha Valley in the spring.

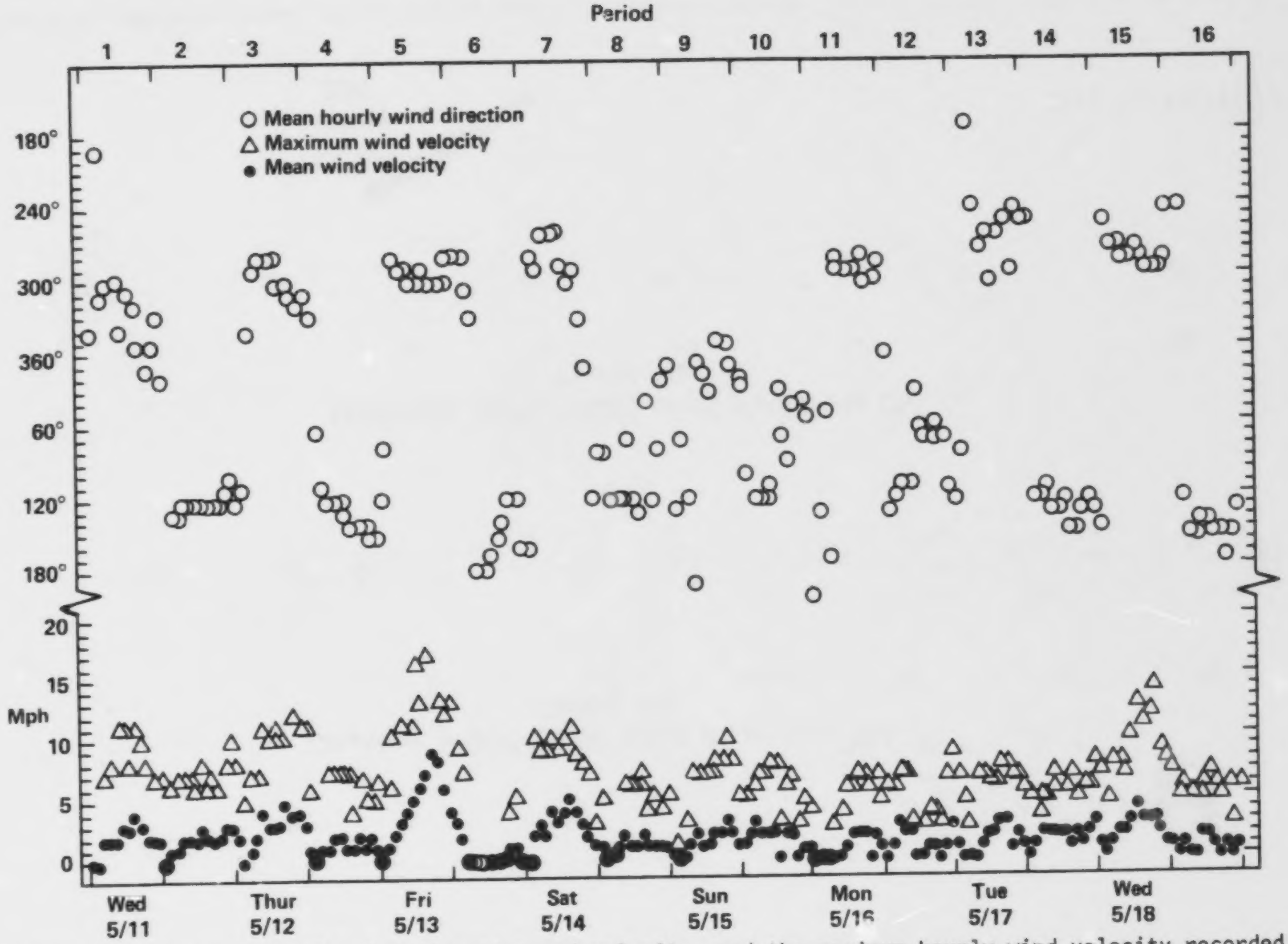


Figure 4. The mean hourly wind direction and velocity, and the maximum hourly wind velocity recorded atop the Federal Building during the sampler intercomparison study.

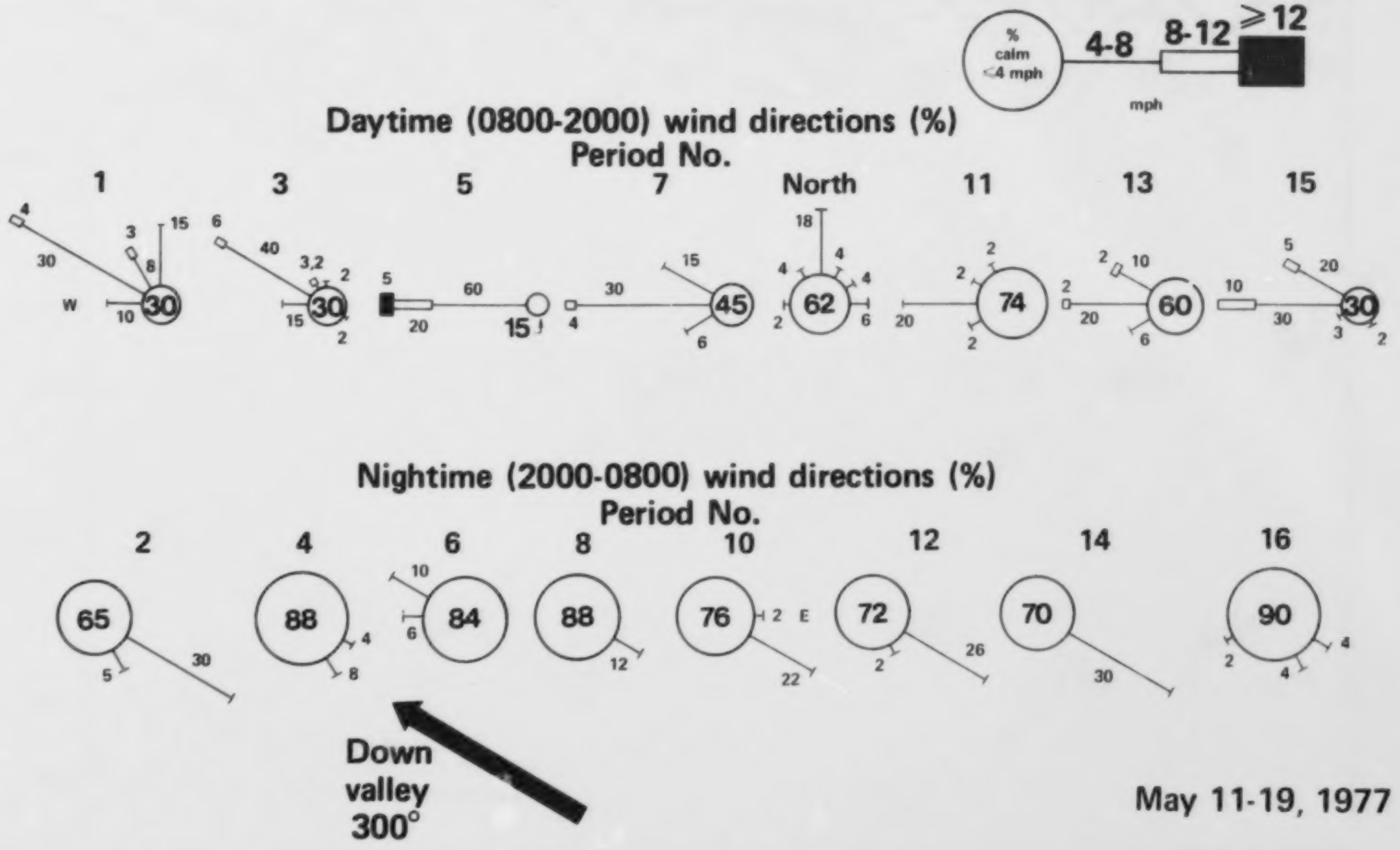


Figure 5. The wind speed and direction results recorded atop the Federal Building shown as wind roses.

SECTION 5

MATHEMATICAL TREATMENT OF RESULTS

CALCULATION OF A MEAN CONCENTRATION

Table 4 listed 21 samplers that reported pollutant concentrations which could be intercompared. Concentrations were reported in micrograms per cubic meter for the mass fractions, and in nanograms per cubic meter for all other pollutants. Since no sampler brought to the study was to be regarded as the standard of comparison, the reported pollutant concentrations from all samplers were assigned equal weights. Thus, a mean concentration can be calculated for each of the 16 periods, for the 13 different pollutants, and for the total, fine, and coarse particulate fractions. Only one participant reported results for coarse nitrate, while thirteen participants reported total lead concentrations.

Since all samplers were accorded equal weight, the calculation of a mean concentration can be regarded as a "composite sampler" concentration. However, there are three effects which can bias the calculated mean concentrations.

First, any sampler can potentially malfunction with the result that less than 16 concentrations values are reported. The remaining values may or may not distort the composite sampler concentration and a priori there is no way to judge which samplers should be included or excluded. Another reason for unreported results might be that the pollutant could not be detected because of poor analytical sensitivity or insufficient amounts collected. Thus, not-detected is not synonymous with zero concentration.

Second, in any large data set there always exists the possibility of outliers. These values may appear "bad" because of sampling errors, analytical technique calibration errors, sampler malfunction, or errors in transcribing results. Also an actual measured value may be quite reasonable, but is identified as an outlier by any statistical tests, because all other values reported happen to be nearly identical. Thus, statistical tests for outlying values should not be applied indiscriminately, but can be used to identify unusual values in very large data sets.

Third, in calculating a composite concentration, the mean value may be biased by duplicate or triplicate samplers if the reported concentrations from these additional samplers all lie to one side of the mean. Thus, mean concentrations can be calculated from all samplers reporting results, or from only one sampler of each type. The influence of these three factors (1) fewer than 16 periods of results reported, (2) outlying values, and (3) multi-sampler bias must be considered in calculating a mean. After defining the equations from which the mean composite concentration is derived, each of the three factors will be discussed.

The mean concentration for any period can be calculated from the simple expression

$$Z_j = \frac{1}{n} \sum_{i=1}^{n} C_{ij} \quad , \tag{1}$$

where C_{ij} is the concentration reported by the i^{th} sampler for the j^{th} period, n is the number of sampler result sets used, and j is the period number ($j = 1, 2, \ldots 16$). The standard deviation associated with Z_j is calculated from

$$S_{zj} = \left[\frac{1}{n-1} \left(\sum_{i=1}^{n} C_{ij}^{2} - n Z_j^{2} \right) \right]^{\frac{1}{2}} \tag{2}$$

There will be 16 Z-mean concentrations for the 39 pollutant size fractions reported (13 pollutants x 3 size fractions).

Fewer Than 8 Results

Because of a number of reasons including sampler malfunction, non-detectable pollutant concentrations, and others, some participants reported fewer than the total of 16 periods expected. Since there is no way to decide a priori which results are "bad" or "good" or for what reasons, the decision was arbitrarily made to eliminate from the mean concentration calculation any result set containing fewer than 8 of the 16 period results for any given pollutant size fraction. Applying this criterion, there were only 4 result sets eliminated out of 139 reported for the total particulate fractions, 4 out of 111 for the small fraction, and 5 out of 100 for the large fraction. Seven of these were because of low to non-detectable pollutant concentrations, leaving only 6 of 350 (< 2%) result sets rejected because of fewer than 8 periods reported.

Outliers

Almost always in large data sets, values can be found which fall well outside the expected statistical spread in the mean. For whatever reasons these values appear "bad", two major decisions are required. First, should a statistical test for outliers be applied and if so which one? Second, if outliers are found, should they be eliminated from the mean indiscriminately, or should some subjective judgement be employed? This is not simply rhetoric since the definition of an outlying value depends on the breadth of the distribution deemed acceptable. If the probability for rejecting an observation is made sufficiently small enough, all values can be made to be acceptable.

Two different statistical tests were used to identify outliers. One is the well-known Dixon criterion (4); and the second, the Grubbs-criterion as developed by Tietjen and Moore (5) for the detection of multiple outliers. The latter is a multi-pass or cylical test in which means are calculated, outliers identified, the mean value recomputed, addditional outliers sought, and etc. The number of cycles and the statistical breath to the mean distribution depend on the number of observations. Application of this statistical test resulted in many values being identified as "outliers" - too many it seemed. Although it appears to be a very sophisticated test, the number of observation sets (result sets) obtained in this study was too few for most of the pollutant species reported. The Dixon criterion when used in the single pass mode is much more conservative, i.e., fewer outliers identified. The Dixon criterion was used with α arbitrarily set equal to 4%. This is the probability assumed in rejecting an observation that really belongs in the group. Any values falling more than 2% high or 2% low will be rejected. The equations which define the Dixon criterion as applied to this study's results can be found in Appendix B.

The Dixon criterion was applied to all result sets submitted. Immediately, punch card errors and recording errors were spotted. Several participants submitted results for the wrong pollutant, or results in ng/cm^2 instead of ng/m^3. These were quickly identified by the outlier criteria. Another participant had 9 of 16 results identified as outliers. Since only 7 of the 16 periods results remained, their results were eliminated from the mean composite calculation. This was the only data set eliminated by the outlier test.

Table 5 lists all those sampler-period results which were identified as outliers by the Dixon criterion. Most of these outlying values can be understood or explained. For example, the selenium concentrations lie near the threshold of detectability, hence wide flucuations are expected. The zinc values occasionally clustered very tightly, allowing even a reasonable value to appear as an outlier. The copper excursions were due to local sources (copper from pump motors), and the excursions observed in certain crustal elements were probably real. The outlying small nitrate values also could be explained (see Section 6). In effect, then, except for the Q-sampler's small sulfur results, which were generally low by a factor of 3, all of the outliers identified were allowed to remain in the calculation of the mean.

Multiple Sampler Bias

There is a potential problem due to some participants having duplicate samplers and others having only a single sampler. If one or more sets of duplicate samplers lie well to one side of a calculated mean, the mean would be biased. To examine this posssibility an alternative mean concentration can be calculated by averaging results from only one sampler of each type. Clearly, the latter mean is defined by a sub-set of the samplers defining the former mean. Statistically, one expects the difference between these two means to show a positive or negative bias if the additional duplicate samplers are high or low. Since the number of samplers contributing to the the subset mean is less than or equal to the full set, the standard deviation in the subset mean is usually greater. Defining the full set of sampler means as Z and the subset sampler means as X, the quantities (Z-X) and (S_x-S_z) can be calculated and compared.

Table 6 shows the results of 592 mean comparisons. Almost as many mean pollutant concentrations decreased as increased when the duplicate samplers were eliminated. As expected S_x is on the average, larger than S_z. Therefore, there is no strong evidence that including duplicate and triplicate sampler results biases the composite Z-means. In general, samplers N and R were lower than the composite mean by about the same amount that samplers C and S were higher, hence these four samplers offset each other and reduced the influence of other duplicate samplers.

TABLE 5. OUTLIERS ACCORDING TO DIXON CRITERION (α = 4%)

Total	Sampler-Period	Small	Sampler-Period	Large	Sampler-Period
SO_4	P-13 a)	NO_3	F-3,5,8,14	Mass	O-8,10 a)
S	K-7 b)	S	Q-4-7,9,12-15 c)	Ti	J-15 d)
Si	J-9 d)	Si	I-9,12 d)	Fe	N-8
Fe	N-8	Ti	M-12;I-8,12	Cu	D-2,9 e)
Cu	D-9 e)	Zn	N-8; S-3	Zn	R-13
Zn	N-8	Se	M-9,11,16; N-8 f)	Se	M-2 f)
Se	M-2,9,11,14 f)				
Pb	J-9; K-9 b)				

a) EPA (Rodes) Hi-Vol Sampler. Reason for high value unknown.
b) FSU Linear Streaker. Apparently an artifact of the averaging process.
c) These data were low because of an unresolved analytical error.
d) Crustal elements. Incorrect subtraction of blank values.
e) Occasional high values of copper due to local sources, see Section 6.
f) Because selenium concentrations were at the threshold of detectability, these values cannot be considered outliers.

RATIO TO MEANS

Once a composite mean has been defined for each pollutant specie and sampling period, it is very useful to normalize all reported concentrations to these composite sampler mean concentrations. This results in a table in which all of the entries are near 1.0. This has numerous advantages. Among them are

(1) Deviations from the mean are more easily observed and can be quickly converted to approximate percentage differences.

(2) Average ratios for all 16-periods for each sampler can be calculated independent of day to day changes in concentrations. A relative measure of a sampler's overall accuracy (how far from 1.0 which is equivalent to the mean concentration) is shown by this average; and

an indication of a sampler's precision may be shown by the standard deviation in the 16-period average ratio.

(3) Appropriate graphs of these average ratios vs samplers reporting allow sampler to sampler comparisons.

(4) Multiple graphs of the type described in (3) allow pollutant to pollutant comparisons independent of their actual aerosol concentration differences (which may be orders of magnitude).

These advantages will become evident upon a detailed examination of the results presented in Section 6.

TABLE 6. MEAN CONCENTRATION CHANGES VS NUMBER OF SAMPLERS AVERAGED

Quantity	Change			Totals [b)]
	+	0 [a)]	-	
(Z-X)	263	77	252	592
$(S_x - S_z)$	344	59	189	592

a) No change is defined as less than a 1% change in the Z-mean or standard deviation, S_z, compared to the X-mean or S_x.

b) A total of 624 period-pollutant-means can be calculated (16 pds x 13 pollutants x 3 size fractions). Since only one sampler reported results for large NO_3 and one sampler remained in the X-group for large sulfate, only 592 comparisons were made.

REGRESSION ANALYSIS

Regression analyses were performed between the results from every pair of samplers, and between each sampler and the composite Z-mean. If a linear mathematical relationship is assumed to exist between two variables (sampler concentrations), then we can write

$$y = a + bx \quad , \tag{3}$$

where y is the dependent variable, and x is the independent variable (the Z-mean, for example). Since in this study both x and y are pollutant concentrations in $\mu g/m^3$ or ng/m^3, the intercept, a, will also be in these units. Standard equations exist for calculating ϵa, the error in a. Similarly, the slope, b, and its error, ϵ_b, can also be calculated. The equations for these calculations are given in Appendix B. The extent to which artifacts exist between any two pairs of samplers, will be indicated by the extent to which $a \pm \epsilon_a$ does not overlap 0, and any consistent bias between any two samplers by the extent to which $b \pm \epsilon_b$ does not overlap 1.0. A measure of one samplers precision relative to another is given by $100\ \epsilon_b/b$ in percent. Another form of this precision is given by the root mean square deviation concentration of the y-sampler from the regression fit $y = a + bx$. It is useful to see this value for all samplers compared to the composite sampler. Finally, it is useful to examine the extent to which the variables y and x are correlated. This is revealed by the correlation coefficient. In this study all samplers attempted to measure the same pollutant concentration, hence their correlation with the composite mean will usually be near 1.0. However, whenever sampler malfunctions occurred and/or few results were reported, the reported results will correlate poorly with the composite mean. The equations used to calculate all of these quantities are given in Appendix B.

SAMPLER RESULT TABLES

The complete set of results from the study is given in Appendix C. Concentration values were reported for 13 different pollutant species in 3 size fractions, the total, the small or fine, and the large or coarse particulate fraction (39 Tables). The sulfur concentration results were multiplied by 3 and combined with the sulfate results to give 3 additional tables. Figure 6 illustrates a portion of one of the 42 tables (small sulfur).

The top most grouping lists the reported concentrations in appropriate units as a function of period (1 through 16) of the study. The alphabetical sampler identification letter is that of Table 4. A dash means no value reported and a concentration value preceeded by a minus sign indicates an outlier value according to the Dixon Criterion ($\alpha = 4\%$). The composite sampler concentration or Z-mean is listed next along with its standard deviation. Any sampler excluded is noted parenthetically, and as discussed above, all outlier values are included in the Z-mean (except for sampler Q, small sulfur). The X-mean and its standard deviation exclude selected duplicate samplers. Those included in this calculation are shown in parentheses.

The next grouping lists all sampler concentrations normalized to the composite Z-mean concentrations. Most of these entries generally lie near 1.0. To the far right, the 16 period average ratio, its standard deviation, and the coefficient of variation (percent error) are shown. An asterisk preceeding any tabular values indicates that the participants reported error for that period allows his value to overlap the Z-mean (1.0). If a participant's value deviates far from 1.0 yet still has an asterisk, this indicates a rather large error; while values close to 1.0 without asterisks may suggest a small error. Below this grouping appears the mean ratios which by definition are always 1.0. However, its standard deviation reflects how tightly clustered all of the reported results are as a function of period. Note that the 16-period average standard deviation multiplied by the average pollutant concentration yields the error given to the far right of the top most grouping.

The lower grouping tabulates results of the regression analysis of each sampler vs the composite sampler (Z-mean). The quantities listed left to right are the intercept and its error in either μg or ng/m^3, the slope and its error, the root mean square deviation in concentration units, and the correlation coefficient.

Appendix C of this report contains only the regression analysis results

```
1                    INTERCOMPARISON STUDY        PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD      1     2     3     4         11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A   4562  2668  3737  2943           42  4336  7912     -  8951     - D
M  EPA  DZUBAY   TF-M   5009  3572  3894  4182  6         8  4695  7586  9298  8606  8687 M
N  EPA  DZUBAY   TF-P   4951  3170  3443  3684  55           4525  7764     -  8612     - N
R  EPA  DZUBAY  MDS-S   4297  3040  3707  3373  574          4683  7362     -  9234     - R
C  LBL  LOO     DICOT   5336     -     -  4123  6572         5571  8475  9532 10125  9019 C
L  LBL  LOO     DICOT   5308  3518  4309  3945  6430          468  8617  9851  9998  8969 L
S  LBL  LOO     DICOT   5244  3693  4274     -  6448           14     -  9577 10146  9094 S
G  UCD  CAHILL  SMDAY   4310  2500  2940  3800  5570  7         -     -     -     -     - G
I  UCD  CAHILL  SFU     3769  2693  3491  3481  7557  72        3  6950  9314  7375  5833 I
Q  STL  DEL/ED  2MASS   1900  1210  1270  -970 -1430 -115       -2090 -1390 -1920  3130 Q

Z MEAN(WITHOUT Q)       4754  3107  3724  3691  6157  7650        7809  9514  9131  8320   5869  626
   STANDARD DEVIATION    548   458   451   416   670   603         591   226   959  1399

X MEAN(D,M,L,G,I)       4592  2990  3674  3670  6225  7851  74       5  9488  8733  7830
   STANDARD DEVIATION    601   512   507   479   829   423  45.          315  1081  1735

RATIO TO Z       PERIOD      1     2     3     4     5     6     7           14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A •0.96  0.86 •1.00  0.80  0.90     - •0.97  0          - •0.98     - D 0.92 0.08  9
M  EPA  DZUBAY   TF-M •1.05  1.15 •1.05  1.13 •0.98 •1.03 •1.01            8  0.94 •1.04 M 1.02 0.06  6
N  EPA  DZUBAY   TF-P •1.04 •1.02  0.92 •1.00  0.90  0.88 •0.98  0.9       -  0.94     - N 0.95 0.05  5
R  EPA  DZUBAY  MDS-S  0.90 •0.98 •1.00  0.91  0.93  0.91 •0.96  0.91        •1.01     - R 0.94 0.03  4
C  LBL  LOO     DICOT  1.12     -     -  1.12 •1.07 •1.06 •1.08          -   •1.11 •1.08 C 1.09 0.03  3
L  LBL  LOO     DICOT  1.12  1.13  1.16 •1.07 •1.04 •1.08 •1.08          - •  1.10 •1.08 L 1.09 0.03  3
S  LBL  LOO     DICOT •1.10  1.19  1.15     - •1.05 •1.0  •1.07          - •1   .11 •1.09 S 1.09 0.05  5
G  UCD  CAHILL  SMDAY •0.91  0.81  0.79 •1.03 •0.90 •1.04 •0.92  1.31 •0..     -     - G 0.94 0.15 16
I  UCD  CAHILL  SFU    0.79  0.87 •0.94 •0.94  1.23 •0.95 •0.95 •1.11 •1.0   1  0.70 I 0.95 0.13 14
Q  STL  DEL/ED  2MASS  0.40  0.39  0.34  0.26  0.23  0.15  0.16  0.14  0.23        0.38 Q 0.29 0.14 47

  MEAN(WITHOUT Q)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00        1.00   1.00
   STANDARD DEVIATION  0.12  0.15  0.12  0.11  0.11  0.08  0.06  0.22  0.08  0    .17   0.11

REGRESSION VS Z         INTERCEPT      ERROR       SLOPE       ERROR   RMS.DEV.  COR.COEF
D  EPA  DZUBAY  MDS-A   -219.166     396.721      0.963       0.070    530.327      0.972
M  EPA  DZUBAY   TF-M    387.016     195.029      0.944       0.031    284.104      0.993
N  EPA  DZUBAY   TF-P     62.634     207.518      0.934       0.036    281.747      0.991
R  EPA  DZUBAY  MDS-S    -95.827     167.455      0.962       0.029    227.354      0.995
C  LBL  LOO     DICOT    266.537     189.194      1.040       0.029    240.356      0.996
L  LBL  LOO     DICOT    195.124     114.091      1.051       0.018    166.201      0.998
S  LBL  LOO     DICOT    325.002     196.595      1.023       0.031    270.438      0.995
G  UCD  CAHILL  SMDAY  -1002.408     731.934      1.170       0.139    880.238      0.942
I  UCD  CAHILL  SFU      449.415     610.244      0.866       0.097    890.555      0.923
Q  STL  DEL/ED  2MASS      0.          0.         0.          0.         0.          0.
```

Figure 6. A portion of one of the tables listing results for the pollutant small sulfur. Complete results for all pollutants can be found in Appendix C. See text for an explanation of the entries.

of each sampler with the composite sampler. Regression analysis results on all pairs of samplers are available from the study director, the EPA project officers, or any of the participants.

SECTION 6

SELECTED RESULTS AND DISCUSSION

PRECAUTIONS IN INTERPRETING RESULTS

The objective of the study was to evaluate sampler performance by intercomparing the reported concentrations of selected pollutant species as measured by the samplers. The measured concentrations contain many factors which influence their magnitude. Before presenting the results, it is worthwhile examining some factors that can influence the concentration values obtained.

In Section 1, Table 4, the various sampler performance parameters were presented. Among the more prominent differences were sampler flow rates, inlet designs, particle size cut-points, and collection substrates. Those samplers which had cylindrically symmetric inlet designs should be insensitive to wind direction, but not necessarily wind speed. Samplers with such inlets will accept particles up to some limiting aerodynamic size. Others which do not have cylindrically symmetric inlets will be wind direction dependent. In comparing total pollutant specie concentrations, the maximum size particles accepted may influence the final concentrations obtained.

Some of the samplers brought to the study separated the incoming air particles into two or more size fractions. In comparing results from these samplers, the particle size distribution will influence the results obtained. A sampler having a fine particle cut-point of 2.5 micrometers cannot obtain the same concentration as one having a 3.5 micrometer cut-point, all other factors being equal. In comparing results for large particle sulfur, for example, a sampler having a cut-point of 2.5 micrometers may record significantly more large particle sulfur than one having a cutpoint of 4.3 micrometers particularly if very little sulfur is associated with particles having diameters greater than 3.0 micrometers. Also some filter substrate materials, particularly fiberglass, will allow the formation of stable SO_4 ions from SO_2 gas which passes through them. This adds some mass and causes an artificial increase in the SO_4 concentration.

Another important factor is the analytical technique, its sensitivity, accuracy, and precision. Supposedly all analytical techniques used are calibrated as carefully as possible. But different calibrations can result even for identical instruments if two different "standards" are used. Thus, even analytical technique calibrations can lead to differences as large as 5%, and possibly 10% depending on the technique.

Clearly, sampler flow rates, cut-points, and analytical techniques can lead to differences in reported concentrations. Other important parameters that may cause differences are the extent of particle bounce-off from sampler walls, sticky vs non-sticky substrates, different methods employed in the initial calibration of a sampler flow rate and cut points, different methods of monitoring sampler flow rates at the field study, screened or unscreened inlets, and possible inhomogeneity in the air actually sampled. These are just a few of the sampler parameters which can lead to differences in the final results. Some of the differences may be explained and removed, other parameters will be unknown and the differences they cause in the results not removable. Therefore, the reader is urged to consider very carefully those factors which can contribute to observed differences, before drawing conclusions about a samplers relatively "good" or "bad" performance.

POLLUTANT CONCENTRATION VS PERIOD

Pollutant concentrations were reported for each 12 hour period in $\mu g/m^3$ for all mass fractions and in ng/m^3 for all other pollutants. Table 7 lists the 16 period pollutant concentration averages and standard deviations for all thirteen species measured. For the total fraction, maximum and minimum values and their standard deviations observed during the 16 periods are also given. For the small and large fractions, only the 16-period averages and standard deviations are tabulated. The sum of the latter two averages is not always equivalent to the total average because some sampler types measured the total fraction, but not either sub-fraction. An inspection of the results shows that large particulate crustal elements have the largest standard deviations. On the other hand, those elements typically found in the small particulate fraction are somewhat better measured even though their absolute concentration is less.

Not all of the various pollutant species measured behaved in the same manner throughout the study. Figure 7 shows several selected pollutant specie composite sampler concentrations (the Z-means) as a function of half day periods for the total and small fractions. The error bars shown represent standard deviations. The slightly displaced squares indicate the small or fine fraction ($< 3.0 \pm 0.5\ \mu m$) Z-mean concentrations. From Table 4 it was clear that there was a wide range in particle sizes selected by the sampler inlets (as well as the fine particle cut-points), hence part of the spread in the standard deviations is due to variable size particles accepted by the different sampler inlet designs and cutpoints. The standard deviations in the crustal elements, silicon, calcium, titanium, and iron, show the greatest variation; mass shows somewhat less variation. Pollutants typically concentrated in the fine fraction show the smallest standard deviations.

Throughout Figure 7 the odd periods represent daytime collections (0800 - 2000 hrs) while the even periods represent nighttime collections (2000 - 0800 hrs). Except for sulfur the lowest pollutant concentrations were recorded during period 9. Note that the silicon and iron concentrations track each other closely, and mass behaves similarly to the crustals, but is not identical. The zinc concentrations were approximately constant except for two large excursions during periods 2 and 4. Lead concentrations peaked Friday and Saturday nights, periods 6 and 8. Sulfur slowly increases as the study progressed except for the 24 hour dip beginning Sunday at 0800. Visibility was good during the beginning of the study, but deteriorated steadily ending in

TABLE 7. 16-PERIOD POLLUTANT CONCENTRATION AVERAGES FROM ALL SAMPLERS REPORTING RESULTS FOR MAY 11-19, 1977

	Total Fraction		Small Fraction	Large Fraction
Pollutant	Avg	Max & Min Values Recorded	Avg	Avg
Mass g/m^3	104 ± 18*	146 ± 23 47 ± 6	55 ± 13	43 ± 15
Nitrate ng/m^3	1880 ± 1000	2860 ± 2400 860 ± 450	1020 ± 760	1090 ± 500
Sulfate ng/m^3	19350 ± 3000	30600 ± 3800 6420 ± 2360	18200 ± 3000	930 ± 400
Sulfur ng/m^3	6640 ± 1000	10800 ± 970 1935 ± 400	5870 ± 630	574 ± 240
Silicon ng/m^3	9950 ± 3650	17600 ± 7200 4000 ± 2100	1140 ± 520	7680 ± 3300
Calcium ng/m^3	2500 ± 900	4200 ± 1500 730 ± 350	300 ± 160	2230 ± 1000
Titanium ng/m^3	250 ± 90	400 ± 100 88 ± 46	44 ± 29	210 ± 100
Iron ng/m^3	1750 ± 500	2400 ± 670 730 ± 240	350 ± 150	1400 ± 600
Copper ng/m^3	88 ± 40	400 ± 70 24 ± 12	80 ± 30	17 ± 9
Zinc ng/m^3	116 ± 22	283 ± 41 62 ± 14	76 ± 13	40 ± 13
Selenium ng/m^3	10 ± 3	27 ± 4 3 ± 1	9 ± 3	1 ± 1
Bromine ng/m^3	236 ± 59	489 ± 126 65 ± 19	190 ± 48	64 ± 23
Lead ng/m^3	1070 ± 180	1660 ± 260 326 ± 93	820 ± 90	220 ± 90

* Standard deviations

an air stagnation alert (throughout the southeastern mountain states) that began 36 hours before the end of the study.

Typically, the small mass fraction constituted about half of the total mass collected; while small silicon and iron constitute only 11 and 20% of their totals, respectively. About 80% of the sulfur and lead are found in the small fraction, while zinc is almost equally distributed 60/40% in the small/large fraction. All of the results from which these plots were made can be found in the complete tabulation of the total, small and large fraction results in Appendix C.

AIR HOMOGENEITY

As mentioned in Section 1 all samplers were arranged in a linear array 1.5 meters from the southeast face of the building. Sampler A was located about 9 meters southwest of the eastern corner of the roof, and sampler U about 9 meters from the southern corner of the building. Two CHAMP samplers, B and U, were duplicates and collected both large and small fractions; samplers C, L and S were the automated dichotomous samplers (ADS); and samplers D and R were the manual dichotomous samplers (MDS). Note that samplers B, C, and D were adjacent while R, S, and U were nearly adjacent. The former group was toward the eastern end; the latter group toward the southern end. Sampler L was located nearly centrally. The three automated dichotomous samplers C, L, and S were brought to the study and used to evaluate the homogeneity of the air sampled on the roof (see Section 4, page 13).

One method of evaluating any possible inhomogeneity in the air sampled is to ratio concentration results from pairs of duplicate samplers. This can be done for selected pollutant species, say mass and the crustal elements in one group, and man-made elements in a second group. Table 8 lists the ratio of pollutant concentrations as obtained from 4 pairs of samplers for three size fractions and two pollutant groups. Ratios obtained from the two ADS pairs for the crustals pollutants in the total and large fraction suggest that about 20% more crustals are collected at the south end relative to the east end. However, the MDS and CHAMP sampler pairs do not observe this dispersion. For the small particulate fraction in either pollutant group there is no dispersion. The MDS samplers suggest a reverse dispersion for the fine particle crustal elements at the east end. For pollutant group B (anthropogenic trace elements) there really is no strong evidence for any south to east dispersion. In retrospect it would have been useful to have operated the ADS samplers side by side before or after the study to verify that they would yield identical results. However, such tests were not carried out.

Results obtained for wind velocity and direction, which were monitored atop the Federal Building, indicated a strong diurnal wind pattern. Winds were predominantly from 300° ± 45° during the day, while at night they were from 120° ± 15°. If the south to east dispersion were caused by the roof penthouses one might expect it to disappear or reverse as the winds changed directions from night to day. Ratios similar to those in Table 8 were obtained for the same pairs of samplers, only grouped according to odd and even periods, and mean values obtained. There was no significant statistical evidence for any diurnal variation of the dispersion. That is, the ADS sampler

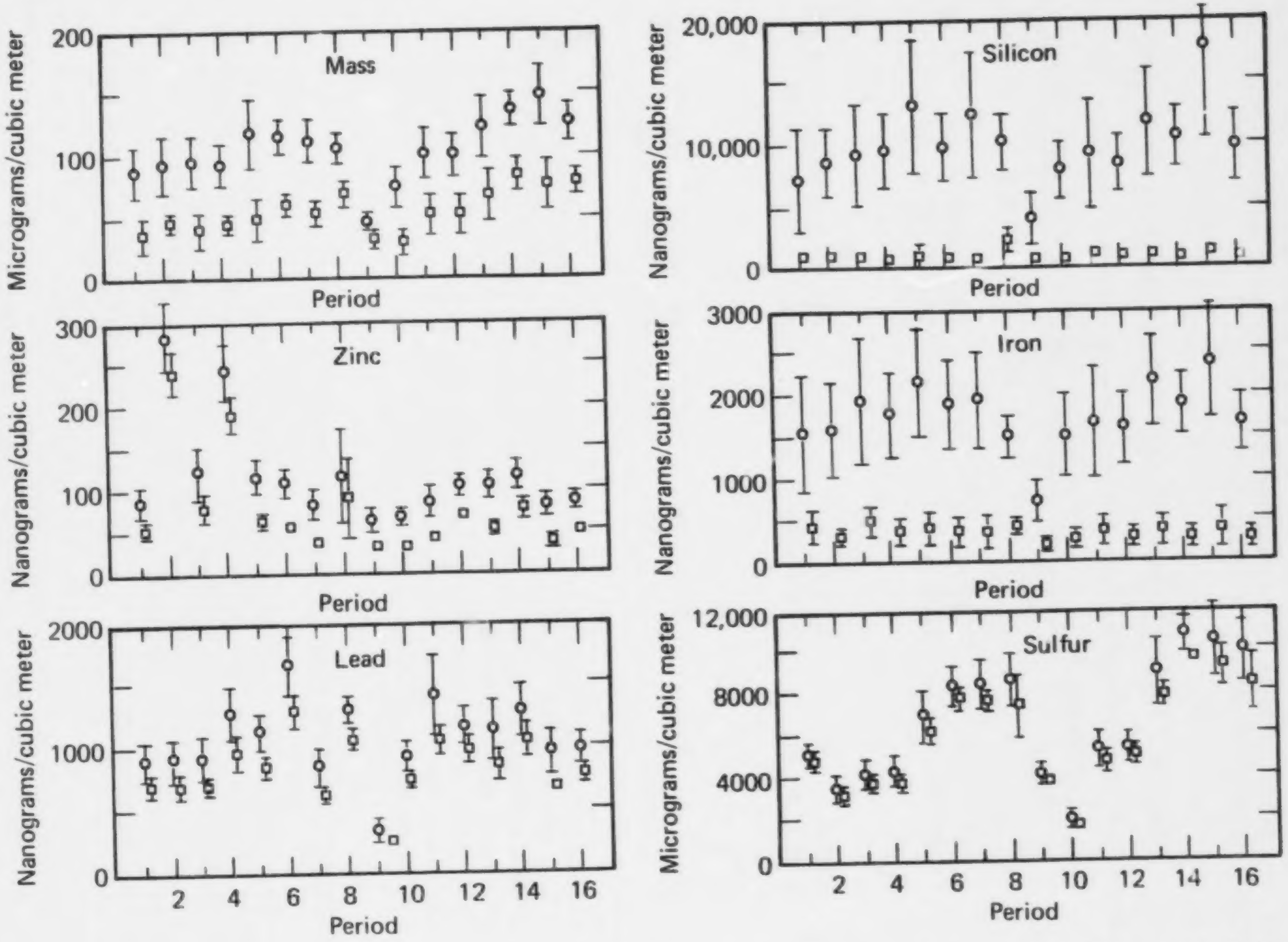


Figure 7. Sixteen 12-hour mean concentrations of all samplers reporting results for total (circles) and small (boxes) particle size fractions for the pollutants mass, Si, Zn, Fe, Pb, and S.

showed the south to east dispersion consistently for pollutant group A, total and large fractions, night or day; while the MDS did not. The observed dispersion, then, appears to be independent of any micrometeorological wind streams associated with the penthouses or roof.

TABLE 8. POSSIBLE SOUTH TO EAST DISPERSION IN THE AIR SAMPLED

Pollutant Group [a]		Sampler Identification and Ratios			
		S/C ADS	S/L ADS	R/D MDS	U/B CHAMP
Total Fraction	A	1.19 ± .05 [b]	1.08 ± .02	0.99 ± .05	0.98 [c]
	B	1.06 ± .05	1.04 ± .05	0.97 ± .12	
Large Fraction	A	1.22 ± .01	1.08 ± .02	1.04 ± .05	1.05 [c]
	B	1.10 ± .08	1.02 ± .08	0.97 ± .09 [d]	
Small Fraction	A	1.00 ± .05	0.98 ± .04	0.74 ± .06 [e]	0.96 [c]
	B	1.03 ± .05	1.04 ± .06	0.98 ± .08	

a) Pollutant Group A contains mass, silicon, calcium, titanium, iron, i.e., the crustal elements. Pollutant Group B contains the anthropogenic elements sulfur, zinc, bromine, and lead.
b) Standard deviation.
c) Only mass was determined by the CHAMP samplers.
d) Excludes the large zinc fraction ratio (0.73).
e) Excludes the small mass ratio (1.04).

ANALYTICAL TECHNIQUE QUALITY CONTROL SAMPLES

From one of the automated dichotomous samplers operated by LBL, a set of 30 fine fraction samples was selected. These samples were analyzed by two referee analysts (Robert Giauque of LBL and Norman Bonner of LLL) for Ca, Ti, Fe, Cu, Zn, Se, Br, and Pb. Silicon was not determined because of significant particle size corrections that must be applied for the soft silicon x-ray. Agreement between the results from the two referee analysts was good. Regression analyses were peformed on the two sets of data and the results are tabulated in Table 9. In two past intercomparison studies (6,7) in which these two referee analysts have participated the LLL values were also observed to be 5% or so lower than the LBL values. Thus, for this study adopted concentration results were used which were essentially mean values of the reported referee results.

TABLE 9. REGRESSION ANALYSIS FITS OF REFEREE ANALYSTS RESULTS

Element	LLL = $(B \pm \epsilon_b)$LBL	+ $(A \pm \epsilon_A)$	No. Values LLL/LBL
Ca	0.915 ± 0.071	66.2 ± 25.9	30/30
Ti	0.933 ± 0.114	8.2 ± 7.7	29/23
Fe	1.003 ± 0.026	-12.0 ± 15.0	30/30
Cu	0.986 ± 0.012	-4.6 ± 4.9	29/30
Zn	0.937 ± 0.007	9.2 ± 2.1	30/30
Se	0.887 ± 0.018	1.2 ± 0.7	28/28
Br	1.063 ± 0.020	-6.3 ± 9.2	30/30
Pb	0.935 ± 0.014	8.9 ± 36.2	30/30
Mean Slope	0.957 ± 0.056		

Sulfur was analyzed on all 30 samples by one of the participants (Loo) and on 6 samples by one of the referee analysts (Giauque). Before the sulfur measurements could be performed by the referee the six filter samples had to be cut down to 2.54 cm diameter circles. Since the sulfur analyses were performed after the samples were cut, there was a possibility that material may have been lost as a result of the cutting process in which case the sulfur data would be biased. Five of the six filter samples were analyzed for sulfur, and then reanalyzed at LLL for the 8 trace elements previously measured. The sixth sample was rendered unmeasurable in trying to cut it. Table 10 shows the results for the LLL reanalysis. Sample 80721 may have been contaminated somehow by a copper-zinc source because the values were unquestionably different afterwards. The selenium concentration on sample 80730 was very low (large error). Otherwise there is excellent agreement before and after cutting. There is evidence that the bromine concentration changed and additional evidence for its loss with time is discussed below. There was excellent agreement between Loo's 5-sulfur results and the LBL referee values, hence Loo's sulfur values were used as reference values for the remaining 24 samples.

TABLE 10. RATIO OF XRF RESULTS FOR CUT TO UNCUT FILTER SAMPLES

$$\frac{\text{Cut Sample Concentrations (ng/cm}^2\text{) by XRFA}}{\text{Uncut Sample Mean Concentrations (ng/cm}^2\text{) by XRFA}}$$

Sample Number	Ca	Ti	Fe	Cu	Zn	Se	Br	Pb	
80721	1.053 ±.167a)	N.D.	0.959 ±.163	1.809 ±.177	1.368 ±.191	N.D.	0.814 ±.203	0.935 ±.142	
80724	0.966 ±.126	0.903 ±.169	0.897 ±.125	1.092 ±.201	0.879 ±.201	0.861 ±.150	0.819 ±.120	0.933 ±.142	
80725	1.062 ±.131	1.288 ±.264	1.125 ±.138	1.081 ±.159	1.023 ±.191	1.000 ±.264	0.912 ±.159	1.052 ±.141	
80730	1.000 ±.168	0.630 ±.226	1.126 ±.157	1.051 ±.150	1.026 ±.145	0.571 ±.566	0.945 ±.157	1.036 ±.141	
80734	0.993 ±.157	1.188 ±.223	0.943 ±.151	---	---	N.D.	---	0.896 ±.141	GRAND MEAN ±error/# samples
MEAN	1.015 ±.041	1.002 ±.297	1.010 ±.108	1.223 ±.394	1.074 ±.208	0.811 ±.219	0.873 ±.066	0.970 ±.069	1.003 ±.209/34
	WITHOUT [ ] Entries			1.028 ±.068	0.976 ±.084	0.931 ±.098			0.979 ±.123/31

a) Standard deviation

Eight sets of three samples each were mailed to the remaining participants. Some of the participants did not make trace element concentration measurements on their own samples, so were not required to measure them on the reference samples. The results for all elements except silicon are shown in Table 11. Except for the Washington University group these results eliminate the analytical technique as a source for any large (> 10%) differences in reported pollutant concentrations. The bromine values appear to be unstable with time and will be discussed more completely below.

TABLE 11. PARTICIPANT RESULTS FROM ANALYTICAL TECHNIQUE QUALITY CONTROL SAMPLES

	S	Ca	Ti	Fe	Cu	Zn	Se	Br	Pb	Mean
Cahill [a]	1.01	1.41 [b]	1.04	1.01	0.90	1.14	0.93	0.91	0.92	0.98 [c]
UCD (3)	±.07	±.26	±.43	±.06	±.01	±.05	±.06	±.05	±.03	±.08
Dzubay	0.93	0.89	1.14	0.96	1.04	0.95	0.96	0.92	0.93	0.97
EPA (3)	±.04	±.06	±.13	±.05	±.13	±.06	±.14	±.05	±.02	±.08
Loo (30)[d]	0.98[d]	1.27	1.33	0.98	1.02	1.10	0.87	1.16[e]	1.03	1.08
LBL	±.04	±.13	±.19	±.05	±.07	±.06	±.14	±.06	±.02	±.15
Hudson	0.89	1.06	1.01	0.94	1.33	1.12	(f)	0.92	0.84	1.01
FSU (3)	±.05	±.16	±.05	±.04	±.44	±.20		±.07	±.05	±.16
Rodes	1.06	-	-	-	-	-	-	-	1.03	-
EPA (2)	±.16								±.02	
Tanner	0.84									
BNL (3)	±.12									
Delumyea	0.76									
WU (3)	±.15									

Burton (EPA) and Mueller (ERT) did not report trace element concentrations.

---

a) The number of reference samples measured is given in parenthesis.
b) The filters were temporarily exposed to a known source of calcium contamination (cement dust).
c) Mean value calculated without including calcium.
d) All 30 reference samples were originally from one of the automated dichotomous samplers. Only five could be compared with the referee results.
e) These bromine values were obtained early, then divided by the referees' results which were obtained later after an apparent bromine loss. See the Bromine Loss discussion below.
f) Selenium concentrations were to small to be accurately measured by PIXE.

AVERAGE SAMPLER RATIOS VS SAMPLER TYPE

Each sampler's 12-hour pollutant concentration was normalized to the Z-means to yield ratios near 1.0. These ratios can be averaged for all the periods to obtain an average sampler ratio for the duration of the study. For example, if the high volume sampler consistently collects more total mass than the composite sampler Z-mean, its mean ratio for the entire 16 periods would be greater than 1.0. Another sampler with a more restrictive inlet would have a ratio less than 1.0. An examination of these mean ratios can show systematic trends, illustrate consistent differences between sampler types, and even give an indication of the accuracies and precisions for groups of samplers brought to the study by an individual participant.

Figure 8 shows results for a composite of four selected pollutant species. The 16-period average ratios are plotted as a function of sampler type. The abscissa lists the sampler identification number (see Table 4). The samplers are grouped by participants and arranged within each group in an east to south direction. The top two plots display those samplers reporting total and small mass. Some participants reported both. The two ordinary Hi-Vol samplers P and T report the highest relative mass, undoubtedly because of their ability to collect larger sized particles (unrestricted inlet size). These two samplers report 50% more total mass than the two manual dichotomous samplers, D and R. The CHAMP samplers, B and U, with inlet restrictions report 15% less mass than P and T. Sampler E, the cyclone unit, also reports relatively lower total mass. For small mass, all of the samplers excluding B and U report an average mean sampler ratio of 0.89 ± 0.03 vs 1.36 ± 0.03 for B and U, a factor of 1.56 times as much mass. This is a large difference and suggests that more than a single sampler performance parameter is responsible. Sampler O (Rodes manual dichotomous reports more variability than do samplers D or R (Dzubay manual dichotomous). Sampler O is an older model.

The middle set of plots display all of the sampler results for total silicon and iron. Note the much larger scatter in these two elements compared to total mass, the larger standard deviations, and the same patterns for groups of samplers for the two elements. Sampler H is anomalously high only for silicon, not for iron (or calcium or titanium). The systematic increase shown by samplers C, L and S - east to south is the same 20% air inhomogeneity discussed above, but it is not evidenced by the ratio of samplers R to D, or U to B (total and small mass). The two tandem filter samplers M and N also record more iron (and titanium and calcium) than silicon, relative to D and R. These two tandem filter samplers operate in a similar manner to the UCD stack filter sampler, I, but record relatively more iron than silicon.

The two lower plots display the behavior of the mean sampler ratios for total and small lead. The tight clustering of the small lead results and the generally smaller standard deviations for both is immediately apparent. Note the lack of statistically significant evidence in samplers C, L and S for the south to east air inhomogeneity. As discussed above the crustal elements exhibited such an inhomogeneity in these samplers, but the fine particles, e.g. sulfur, lead, and zinc, did not. Once again, the pattern of certain groups of samplers high, others low, is repeated. Thus, a given participant has reproducible results regardless of which kind or type of sampler he operates, but apparently there are real group to group calibration differences. For example, LBL (samplers C, L, and S) reported 10% more lead in the analytical technique control samplers (Table 11) than did EPA (Dzubay-samplers D, M, N, and R) or UCD (samplers G, H and I). If an appropriate correction is made to their small lead average ratios averages there is even better agreement in the overall results. However, how does one correct for the fact that the fine particle cut-points of samplers C, L, S, and I are about 2.5 micrometers, versus 3.5 micrometers or greater for samplers D, M, N, R and G? The former should record less small lead, not the same, unless there are yet other compensating

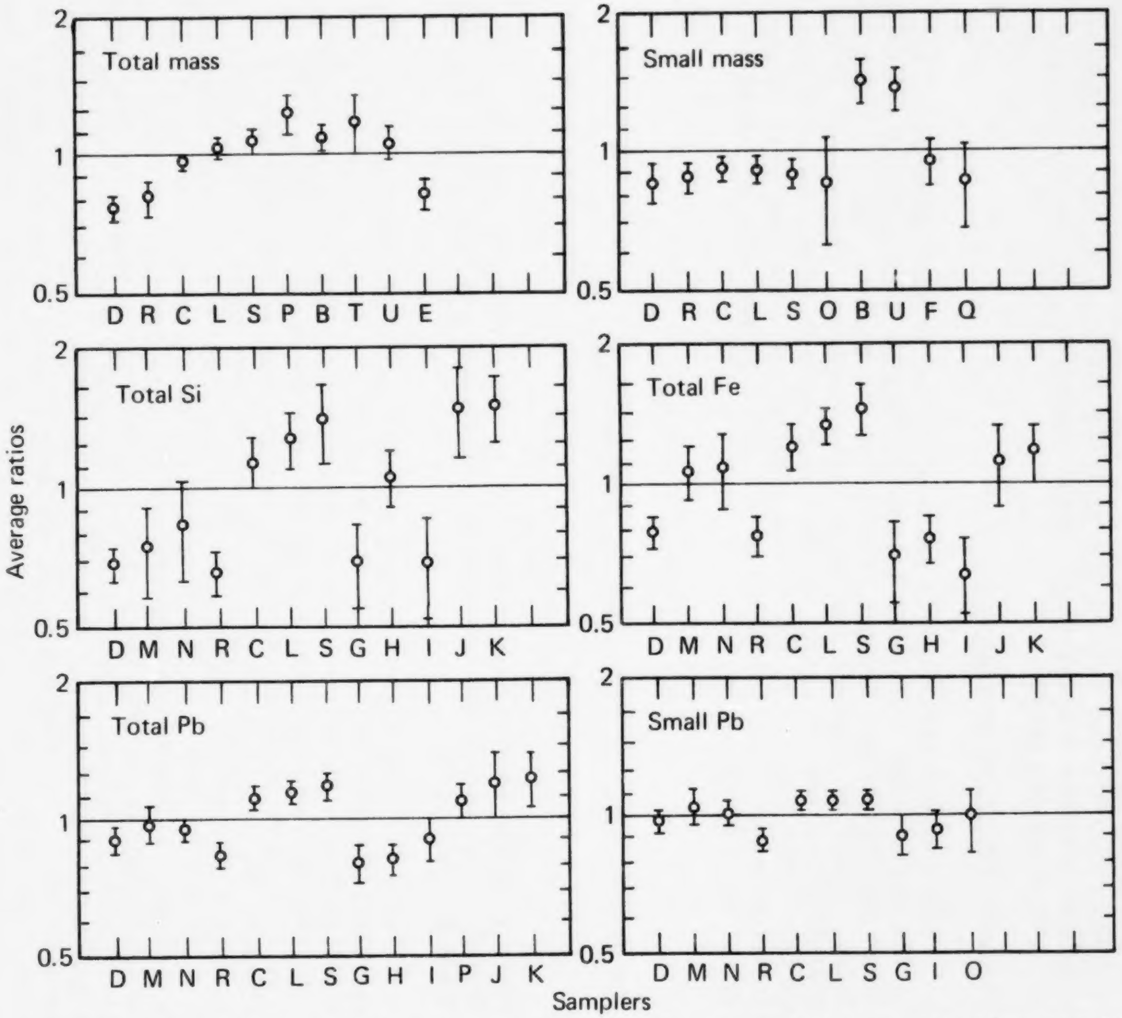


Figure 8. The average ratio vs sampler type. Each sampler reported concentration results for up to 16 periods. Each reported result was normalized to the Z-mean and averaged over the number of results reported to yield the ratios and standard deviations shown here.

)

factors. For total lead concentrations inlet particle size restriction differences may be invoked to explain any remaining differences. Sampler O, which operates on the same principle and has the same flow rate as D and R, is less precise. It also shows a larger variation for small mass than did D and R.

Figure 8 is an example of the kind of comparison that can be drawn for the pollutant species measured at the intercomparison study. The foregoing discussion points out some of the striking differences, and in several cases, advances possible explanations. Other comparisons of sampler average ratios will be discussed below.

PAIRWISE PRECISION OF SAMPLERS

There were 6 participants who brought two or more samplers of one type to the field study. Of these 4 reported results that could be intercompared. Since one participant brought triplicates and another, two different duplicates, 7 sets of samplers can be pairwise compared. One measure of the precision of one sampler versus another is contained in the error on the slope of the linear regression fit to the results from both samplers. Since a regression analysis was performed on all pairs of samplers, the data are available. In the expressions

$$y = a + bx \text{ or } x = c + dy \tag{4}$$

the percent error or precision, P, is given by

$$P = 100\, \epsilon_b/b = 100\, \epsilon_d/d \tag{5}$$

where ϵ is the error in the slope b or d. Note that, in general, $b \neq d$, nor does $\epsilon_b = \epsilon_d$, unless the correlation coefficient and both slopes are nearly exactly equal to 1.0.

Table 12 lists the precisions of the 7 pairs of samplers for selected pollutant species in the three size fractions. Of course, not all of the samplers were able to measure each of the size fractions hence the blank entries. For example, samplers J and K measured only the total fractions. The best precisions were obtained on fine sulfur and lead as was suggested by the standard deviations shown in Figs. 8 and 9. For these two pollutants, the automated dichotomous samplers obtained excellent precision or reproducability (1.4 to 2.3%). When the good to excellent precision obtained by the manual and automated dichotomous samplers for the fine particulate fraction is compared to results for the large fraction, there is a suggestion that large particulates are not as easy or reproducible to collect. In addition, it appears that the automated dichotomous sampler, S, did not behave as uniformly as did C or L. Perhaps there are variable amounts of particle bounce off or other loss mechanisms associated with large particles in dichotomous samplers; or differences between sampler inlet designs.

Appendix C contains all of the reported results for all pollutants, participants, and periods. However, the only linear regression analysis results included are those for each sampler versus the composite sampler (Z-mean).

Detailed regression analysis results for all pairs of samplers can be obtained from the study director, one of the EPA project officers, on any of the participants.

TABLE 12. PAIRWISE INTERCOMPARISON OF SAMPLER PRECISIONS (%)

Fraction	Pollutant	Burton a) B vs U	Dzubay b) M vs N	Dzubay c) D vs R	Loo d) C vs L	Loo d) L vs S	Loo d) C vs S	Hudson e) J vs K
TOTAL	MASS	6.2		10.6	4.6	8.9	8.3	
	SULFUR		7.3	5.9	1.5	1.8	2.3	5.7
	IRON		14.3	8.2	9.0	15.6	11.8	12.6
	LEAD		5.7	5.1	1.7	2.7	2.8	11.2
SMALL	MASS	4.8		7.0	2.5	3.4	4.1	
	SULFUR		5.0	6.1	1.5	1.9	1.9	
	LEAD		5.3	3.3	1.7	1.4	2.3	
LARGE	MASS	15.2		18.5	8.0	13.1	11.0	
	IRON		13.1	9.3	9.2	17.8	11.8	
	ZINC		14.5		8.0	30.0	14.2	

a) The CHAMP sampler with inlet size restrictions and one size cut.
b) The tandem filter units; however, different substrates were used.
c) The manual dichotomous samplers.
d) The automated dichotomous samplers.
e) The linear streaker samplers, one with 0.4 μ nucleopore, the other with 0.2 μ nucleopore substrate filters.

SULFUR-SULFATE COMPARISONS

Recently it has been shown (8) that sulfate concentrations can be obtained by determining the elemental sulfur concentration and multiplying by three. Figure 9 shows an intercomparison of the sulfur and sulfate concentrations as reported by the various participants. The sulfur concentrations were multiplied by three, combined with the sulfate results, and a combined Z-mean concentration determined. Then, the normalized ratios were calculated for each period, and regression analyses were performed on the combined result set. These results are included in Appendix C. The 16-period average sample

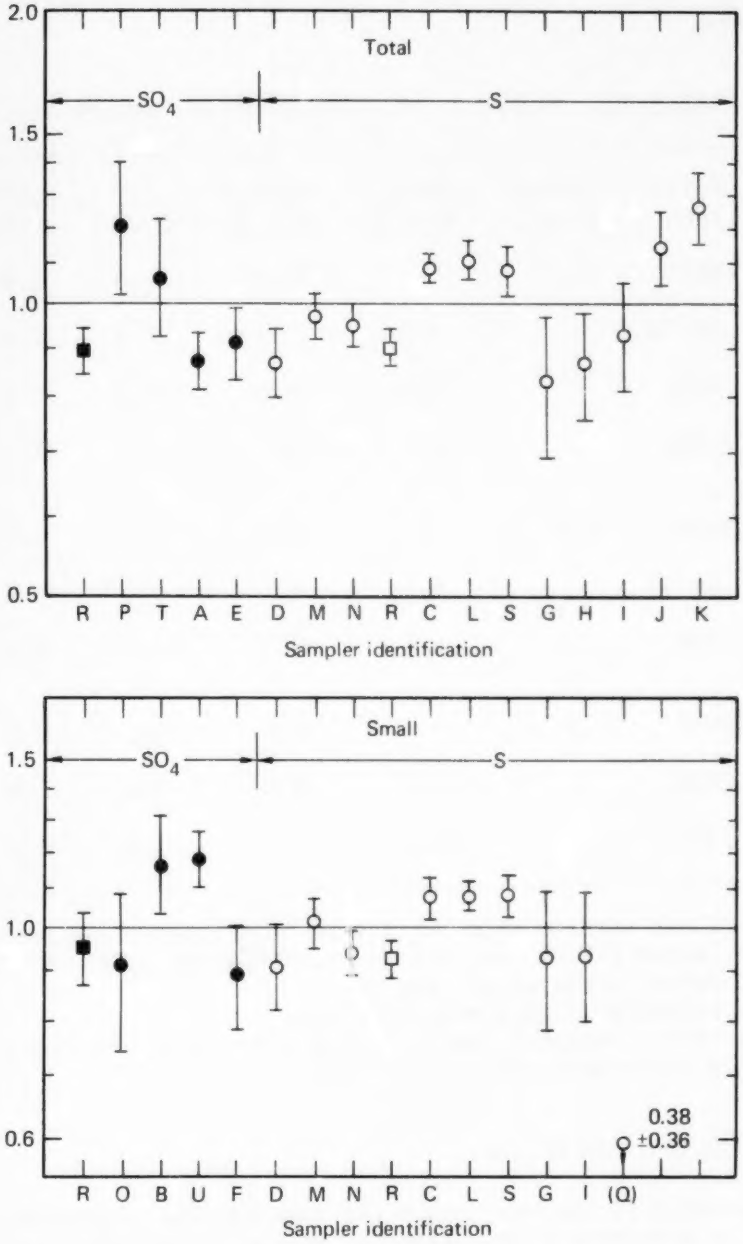


Figure 9. 16-Period average sampler ratios for sulfur and sulfate combined. It was assumed that the determined elemental sulfur concentration times 3 is equivalent to determined sulfate concentration. Only one sampler, R, reported both. Participant using sampler Q reported results which were low.

ratios are plotted vs sampler type for total and small sulfate-sulfur. Filled symbols represent sulfate, open symbols sulfur. Only one participant (Dzubay-EPA) measured both for the same sampler (R). It is assigned a square symbol versus circles for all other samplers.

Sulfur occurs predominantly in the small fraction; and comparison with the small lead results shown in Figure 8 reveals the same samplers are relatively high and low. Samplers C, L, and S suggest no south to east inhomogeneity for small sulfur. Dzubay's group (D, M, N, and R) and the UCD group (G, H, and I) report on an average 10% lower concentrations than the LBL group. However for sulfur, Table 11 indicates that there is not a 10% difference in the analytical technique quality control results for these three groups as there was for lead. Sampler G (the Sierra Multiday - UCD, fine cut point $\leq$ 4,3 μm) reports only 5% as much sulfur as does sampler I (stacked filter unit, UCD, fine cut point $\leq$ 2.6 μm) in the large (coarse) particles. Yet for total sulfur the former two groups are lower than the LBL values by about 18%. Therefore, from the total sulfur and lead results there appears to be at least a 10% difference between what samplers D, M, N, R, G, H, and I collect and what C, L, and S collect. Samplers J and K, the linear streakers, also report relatively more sulfur.

For the total sulfate results, the two EPA Hi-Volume samplers, P and T, are 28% higher than the average of the three remaining samplers R, A, and E. (Note that sampler A is a Hi-Volume sampler, which used phosphoric acid treated filters.) Similarly for small sulfate, the two samplers, B and U are 28% higher than the average of the three remaining samplers R, O, and F. This 28% increase in both the total and fine fraction results may be due to artifact formation (9) of SO_4 from SO_2 by the fiberglass filters used in samplers P, T, B, and U. The standard deviations in the sulfate determinations do not appear to be as good as those for total and small sulfur ($\pm$ 12% for SO_4 vs $\pm$ 8% for S). If the sulfate to sulfur ratio is calculated from the total and small concentration results instead of assuming it to be 3.0, the 16-period means are 3.03 ± 0.34 for total sulfate to sulfur, and 3.11 ± 0.23 for the small fraction. Thus the assumption of obtaining sulfate concentrations from elemental sulfur results multiplied by three, is supported by results obtained in this intercomparison study.

NITRATE RESULTS

An inspection of the reported results in Appendix C for total or small nitrate concentrations reveals a number of strange variations in reported concentrations. For total nitrate the sampler pairs R and T showed higher nitrate concentrations relative to themselves during the day (odd periods) than at night (even periods). The samplers A and E relative to themselves showed the opposite pattern, that is, higher nitrate concentrations at night.

Nitrate concentrations in the small fraction were measured by samplers R, B, U, and F; coarse nitrate was measured by only sampler R. Samplers E and F operate similarly except for fine particle cutpoint. No diurnal pattern similar to that recorded for the total fraction was evident for those samplers reporting small nitrate. Except for periods 1, 14, and 16, sampler R reported nitrate concentrations below their detectability limit of 50 ng/m^3, compared to concentrations of nearly 4000 ng/m^3 reported by sampler F for periods 3 and 8.

There are two hypotheses which may explain the wide disparity of nitrate results. The results varied by a factor of 4 to 9 for total nitrate concentrations and up to two orders of magnitude for the fine fraction nitrate concentrations. Neither hypothesis invokes problems with nitrate determination after collection and extraction since all investigators determined nitrate by either a reduction-colorimetric technique or by ion chromatography. Cross-checks by both methods of the same extract from samples derived from sampler A yielded roughly equivalent results: mean (IC [NO_3^-]/colorimetric [NO_3^-]) = 1.03 ± 0.57.

One hypothesis is that the differences in nitrate levels reported are due to the presence of nitric acid vapor and/or NO_2 in the sampled air, which was collected with varying efficiency depending on the filter material used, and analyzed as nitrate. Based on the work of Spicer (10) on nitric acid collection efficiency one would predict total nitrate values for the reporting samplers (R, T, A, and E) which increased in the order R (Teflon) $\leq$ A (acid-treated quartz) < E (Teflon-coated glass) < T (glass fiber). The actual order was R < T < A < E and it is necessary to introduce other explanations for the observed nitrate concentration order.

A second explanation is that already-collected nitrate-containing particles may be impacted by acidic sulfate particles resulting in the topochemical reaction

$$HSO_4^- + NO_3^- \rightarrow HNO_3^{\uparrow} + SO_4^{2-} \qquad (4)$$

releasing nitrate from those filter materials which, by reason of surface neutrality do not adsorb nitric acid vapor. This might explain why, for example, the total nitrate values of sampler A sometimes are close to those of sampler R (periods 7, 13; acidic sulfate present) while at other times sampler A values approximate those of sampler E (periods 4 and 6). But this hypothesis does not explain the relatively low results of sampler T. Thus, results from this study would suggest that further extensive laboratory and field studies are required before credible nitrate concentrations can be quoted for ambient aerosols.

PARTICLE BOUNCE

Recently, John et al (11) described tests on the filtration of solid particles by Nuclepore filters in which evidence for the phenomenon of particle bounce was presented for tandem or stacked filter units. The mechanism for this phenomenon is pictured as solid particles nominally in the coarse fraction rebounding from the filter surface, being re-entrained in the flow, penetrating the filter, and being collected as part of the fine fraction. By contrast liquid particles stick to the filter surface inihibiting the bounce phenomenon. Thus, the collection efficiency assumed for the coarse or fine fraction may become dependent on the physical state of the aerosol particles collected, and possibly on the substrate used.

Results were reported by two groups that used either Tandem Filters (TF) or Stacked Filter Units (SFU). These two samplers operate similarly; however, their fine cut points were different, 3.5 μm for the TF and 2.6 μm for the SFU. Nevertheless, some evidence for the bounce of coarse particles into the fine fraction can be found for these samplers if a comparison is drawn with other samplers having similar fine cut points. The manual dichotomous samplers had a 3.5 μm fine cut point, while the automated dichotomous samplers had a 2.4 μm fine cut point. By ratioing the results reported for one sampler to another for pollutants found predominently in the fine fraction, e.g., Zn, Pb, and S; and then for those found primarily in the coarse fraction, e.g., Si, Ca, and Fe, a relative measure of bounce into the fine fraction can be obtained. Table 13 lists the ratios of 16-period averages from just the small fraction results for selected samplers. For example, samplers M and N obtained 16-period average ratios of 1.13 and 1.03 respectively for Zn (see results, page 132, Appendix C), while D and R obtained 0.99 and 0.88, respectively. Ratioing the sum of (M + N) to (D + R) yields the ratio of 1.16 shown for Zn.

TABLE 13. COARSE PARTICLE BOUNCE INTO THE FINE FRACTION

Selected Sampler Ratios of 16-Period Average Small Fraction Results

	Element				Element				
	Zn	Pb	S		Si	Ca	Fe		
% in Small Fraction[a]	57	77	90	Mean Fine	11	12	20	Mean Coarse	$\frac{\text{Mean C}}{\text{Mean F}}$
$\frac{M+N}{D+R}$[b]	1.16	1.11	1.06	1.11 ±.05	1.45	2.53	2.10	2.03 ±.54	1.83
$\frac{3(I)}{C+L+S}$[c]	0.88	0.86	0.87	0.87 ±.01	2.54	1.70	1.44	1.89 ±.57	2.17
The coarse particle content in the fine fraction for the tandem or stacked filter samplers relative to the manual or automated dichotomous samplers appears to be about 2.									2.00 ±.17

a) From Table 14 (page 48).

b) M and N are the Tandem Filter Samplers (Dzubay) and D and R are the Manual Dichotomous Samplers (Dzubay). The 16-period average ratios for individual samplers and particular pollutants can be found in Appendix C.

c) I is the Stacked Filter Unit (Cahill) and C, L, and S are the Automated Dichotomous Samplers (Loo).

Column 5 in Table 13 gives the mean ratio for three of the elements characteristically found in the fine fraction, while column 9 gives the mean ratio for three elements characteristic of the crustal fraction. It appears that tandem filters M and N obtain 11% more fine pollutant concentration than D and R, the manual dichotomous samplers while the stacked filter unit obtains 13%

less than the automated dichotomous sampler. The small percentage differences for Zn, Pb, and S are not the focus of the particle bounce question. Continuing, column 9 shows that M and N record twice as much Si, Ca, and Fe as do samplers D and R, while sampler I records almost twice as much as samplers C, L, or S. Finally, if the mean coarse results are ratioed to the mean fine results (last column), any sampler bias or normalization differences are removed. The average mean ratio shown in the bottom section of Table 13 indicates that there is about twice as much coarse particle content in the fine fraction for the tandem and stacked filter units relative to the manual and automated dichotomous samplers. Once again, the very excellent agreement in pollutant concentrations obtained by all of the sampler types at the study for fine lead, sulfur, and zinc would indicate that the crustal particle increases in the fine fraction observed for the tandem and stacked filter units can be attributed to particle bounce from the coarse filter onto the fine filter.

There is also some evidence for particle bounce in another sampler that collects particles by inertial impaction. The CHAMP sampler uses a 26 μm cutoff inlet, a glass fiber filter covered impaction stage and backup filters designed to collect particles in the 0-3.5 μm and 3.5-26 μm ranges. Compared with other samplers the CHAMP sampler collected more mass in the fine fraction and relatively less mass in the coarse fraction. This is consistent with a particle bounce phenomenon that has been observed in previous field studies when dry surfaces were used as impaction plates (12). Because of the bounce problem, overestimation of the crustal materials in the fine fraction can occur depending on the sampler type, and any attempt to measure the acidity of the fine particle fraction would be compromised due to the presence of alkaline crustal elements.

LOCAL SOURCES OF COPPER

Thirty nine samplers were assembled on the roof of the Federal Building within approximately 18 meters. This is an average of one-half meter separation between samplers, much closer together than samplers would normally operate in monitoring programs. Precautions were taken to vent the exhaust of selected samplers over the edge of the roof if they were suspected of causing problems. Several participants claimed filtered exhausts. In spite of the precautions taken there appears to have been several localized sources of copper, probably from winding dust generated in several sampler pump motors.

Copper and zinc are neighboring elements in the periodic chart (Z = 29 and 30, respectively) and their mean concentrations throughout the study were comparable (90 ± 40 and 120 ± 20 ng/m^3 - totals, and about 80 ng/m^3 each-small). Their respective K x-rays are not considered soft and are easy to excite via the several x-ray fluorescence analysis techniques used to obtain the concentrations from the collected particulate matter. Thus, they would appear to be excellent monitors of each other if one assumes their behavior as aerosols are similar. As has already been mentioned in the previous sections, the zinc pollutant levels were, along with sulfur and lead, among the most consistently and accurately measured. This is illustrated by the two graphs shown in the top half of Figure 10. These plots show the 16 period average ratios for total and small zinc obtained by all those samplers reporting trace elements. The standard deviations on the total fraction are

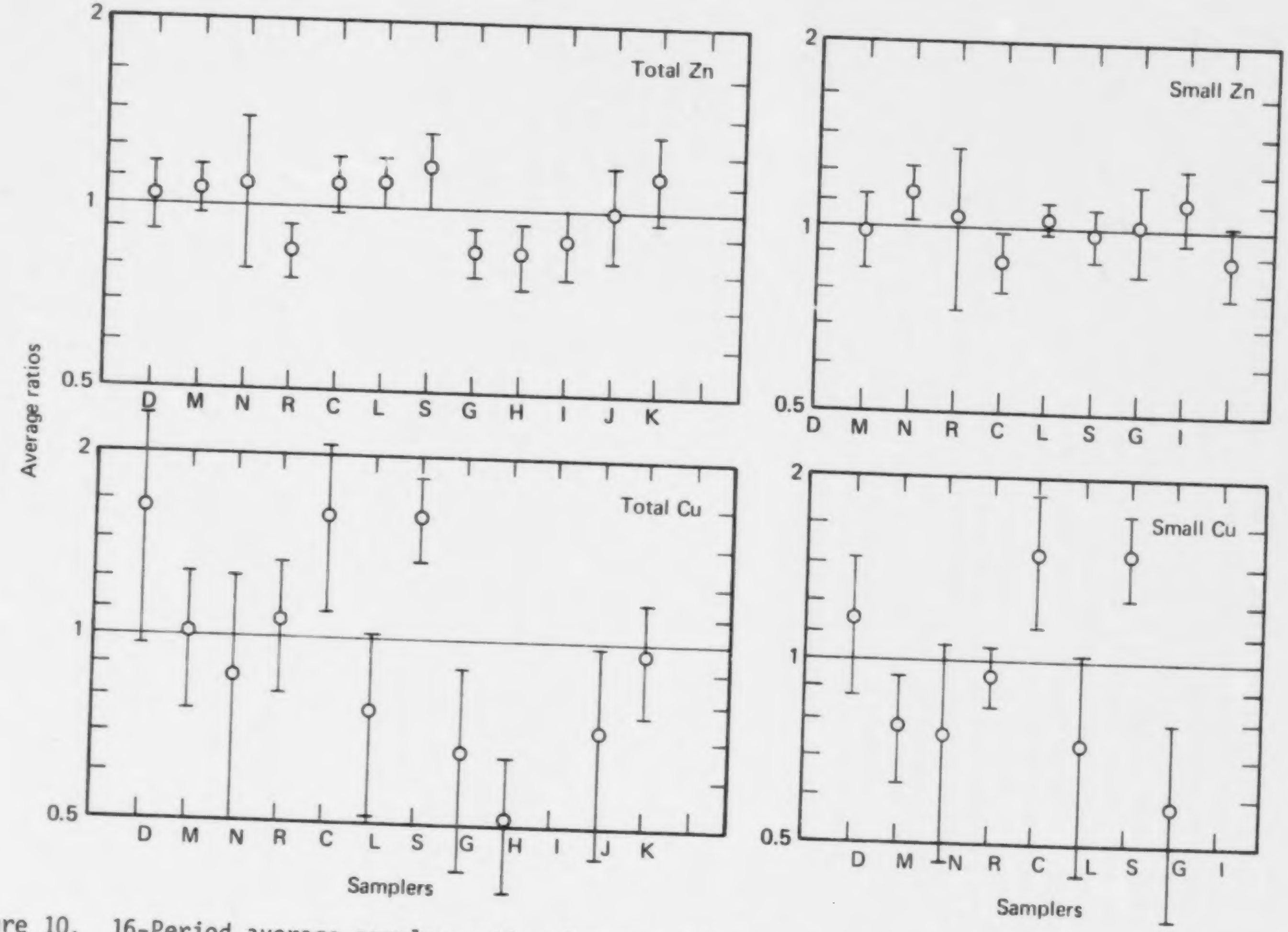


Figure 10. 16-Period average sampler ratios for zinc and copper. The zinc concentrations appear to be accurately determined; while copper concentrations show large fluctuations. This was probably due to nearby high-volume sampler pump motor exhausts which caused localized copper ''hot'' spots for samplers D, C, and S.

comparable to those for the small fraction (indicating that even the large zinc particles were well behaved).

These two graphs are to be compared to the lower half of Figure 10 which shows similar results for copper. Note that samplers M, N, and L report approximately equivalent concentrations for total and small, zinc and copper. These samplers are centrally located. Samplers C and S report twice as much small and large copper as L, while the nearly adjacent samplers D and R report less than twice as much as M and N. This decrease in recorded concentration towards the center suggests the outer samplers A and/or B, and T and/or U - all CHAMP or high volume samplers - may be responsible for the localized copper source. These samplers have the highest flow rates. Two additional high volume samplers were in permanent operation by the West Virginia Air Pollution Board about 2 meters to the southwest of sampler U. This makes a total of 3 high volume samplers to the southwest of sampler S, and only one to the northeast of sampler C, yet the concentrations recorded by S and C are nearly the same. This suggests a rapid decrease in localized concentrations levels with distance. Note also that sampler D was 0.7 m inwards and adjacent to C, while R was 1.3 m inwards and NOT adjacent to S (see Table 3). Since no trace element concentration levels were evaluated for any of the CHAMP or high volume filter samples, it is not known whether these samplers can induct their own emissions. This can probably happen, but will be dependent on meteorological conditions.

There also appeared to be a strong local source of copper and its concentrations were highest during some of the even periods (2000-0800 hrs). From the diurnal wind patterns this places the source southeast of the Federal Building. For periods 2, 4, 12, 14, and 16 mean copper concentrations varied from 80 to 400 ng/m^3 and averaged 200 ng/m^3. The other three even periods averaged 38 ± 6 ng/m^3; while all odd periods except 13 and 15 averaged 28 ± 6 ng/m^3 (13 and 15 averaged 54 ± 6 ng/m^3). Eliminating all results from the five high concentration even periods, and calculating an average concentration value for samplers (D, C, and S) less samplers (M, N, R, L, G, H, J, and K) yields 32 ng/m^3 additional total copper collected by samplers D, C, and S. Almost 95% of the total copper seen during periods 2, 4, 12, 14, and 16 was contained in the small fraction ($\leq$ 3.5 μm); whereas only about 60% of the pump motor copper is contained in the small fraction.

BROMINE LOSS

Thirty fine particulate samples were selected from one of the automated dichotomous samples. These particulate samples were collected on teflon filter substrates having 1 μm pore sizes and were used as analytical technique quality control samples. Results obtained by the participants were presented above. It was mentioned that a possible bromine loss with time may have occurred on these substrates. This evidence comes from four measurements. First, the original measurement of bromine concentration on all 30 samples by Loo when normalized to the lead concentrations gave 1.19 ± 0.10. Second, the LLL value obtained for Br to Pb one month later gave 1.14 ± 0.03. Two months later 5 of the 30 samples when remeasured after cutting gave 1.02 ± 0.10 for the Br to Pb ratio. Finally, six months after Loo's original measurement, he remeasured 2 of the 24 samples that were mailed out and obtained 1.00 ± 0.03

for the relative bromine to lead concentration. In this last measurement Loo also observed a 12% loss of chlorine. Thus, it appears that fine fraction lead bromochloride deposited on teflon filter substrates may require two to six months to stabilize after deposition.

DIURNAL VARIATIONS IN POLLUTANT CONCENTRATIONS

Because of the regular and dramatic wind shifts of nearly 180° at approximately 9 am and 9 pm each day, it is worthwhile examining the reported pollutant concentrations for any day/night variations in the size fraction concentrations. These variations are easily obtained from the composite sampler concentrations or Z-means for the totals and two size fractions reported. Odd periods correspond to daylight hour collections (0800-2000 hrs); while even periods correspond to predominantly nighttime collections (2000-0800 hrs).

Table 14 lists the percentage of selected pollutants found in either the small or large fraction. The tabular entries are recorded in percent. The second column lists the 16-period average percent of pollutant concentration measured in the small fraction, exceptions as footnoted. The results under column three indicate that perhaps as much as 12% more small fraction mass is collected at night as during the day. The crustal elements are definitely concentrated in the large fraction, and only a suggestion of any diurnal variation is found. Note that the sum of the small and large fractions for the silicon and titanium percentages do not total to 100%. This bias is introduced by samplers which report only total trace elements. The local sources of copper were discussed earlier. Selenium is not entered in this table. Its concentrations were very low, were concentrated 88% in the small fraction, and showed no diurnal variation. During periods 13 and 11 selenium concentrations increased to 2 and 3-times the typical concentrations of $10 ng/m^3$ observed. Zinc also showed three excursions above normal during periods 2, 4, and 8. Otherwise about 60% of it is found in the small fraction. Bromine and lead are two well known pollutants associated with the internal combustion engine. They show evidence of a diurnal variation. The recorded bromine concentration did increase to about twice the average observed concentrations during period 2, indicating a local non-automotive source. There appears to be 20% more bromine collected at night. One possible explanation is that the lack of sunlight allows more bromine to remain in particulate form, while during the day more of it is converted to a gaseous form.

Period 8 and 9 appear to yield anomalous Z-mean ratios for all of the crustal elements. These two periods were also the least normal in terms of the typical diurnal wind patterns (see Figures 4 and 5); and period 9 was unusual because the wind was nearly calm and shifted constantly (see Fig. 5).

TABLE 14. PERCENT OF POLLUTANT IN THE SMALL OR LARGE FRACTION

Pollutant	% in Small Fraction	% in Small or Large Fraction Day, Night, Fraction[a)]	Comments
Mass	51 ± 7[b)]	48 ± 6, 54 ± 8, small[b)]	Pd. 8/9 high, 67% small
S + SO_4	90 ± 3	No diurnal effect	Pd. 8/9 normal
Silicon	11 ± 3[b)]	76 ± 5, 84 ± 3, large[b)]	Pd. 8/9 low, 57%-large
Calcium	12 ± 2[b)]	87 ± 2, 93 ± 4, large[b)]	Pd. 9 low, 68%-large
Titanium	17 ± 2[b)]	86 ± 6, 89 ± 2, large[b)]	Pd. 8/9 low, 72%-large
Iron	20 ± 3[b)]	77 ± 3, 84 ± 3, large[b)]	Pd. 8/9 low, 68%-large
Copper	See discussion on local sources of copper, page 44		
Zinc	57 ± 7[c)]	55 ± 7, 60 ± 7, small	Pd. 8/9 normal
Bromine	79 ± 9[d)]	72 ± 7, 86 ± 3, small	20% more Br at night
Lead	77 ± 4	74 ± 2, 79 ± 3, small	Pd. 8/9 normal
Br/Pb	20 ± 4[d)]	18 ± 3, 23 ± 3, small	

a) The plus or minus value is the standard deviation. Small or Large refers to the percentage of either the small or large fraction (Z-mean) found relative to the total (Z-mean).

b) Periods (Pd.) 8 and 9 were omitted from calculations because of anomalous percentages and unusual meteorology (see text).

c) Periods 2, 4, and 8 were omitted from the calculation. During these periods 87, 79 and 79% respectively, of the total zinc was recorded in the small fraction. A local source of zinc probably caused the dramatic increase in zinc concentrations recorded during these periods.

d) Periods 2 and 10 were omitted from the calculation. The bromine concentration increased dramatically during period 2. The bromine to lead ratios went to 61 and 33%, respectively, for periods 2 and 10.

REFERENCES

1. Cooper, J. A. Workshop on X-Ray Fluorescence Analysis of Aerosols. Battelle Northwest Laboratories Report, BNWL-SA-4690, 1973.

2. Proceedings of this conference published in: X-Ray Fluorescence Analysis of Environmental Samples. T. G. Dzubay, ed., Ann Arbor Science, Ann Arbor, Mich. 48106, 1977, 310 pp.

3. Kanawha Valley Air Pollution Study, EPA-APTD 70-1, U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, March 1970, 380 pp.

4. Dixon, W. J. Processing Data for Outliers. Biometrics: 22, 74-89, 1953.

5. Tietjen, G. L. and R. H. Moore. Some Grubbs-Type Statistics for the Detection of Several Outliers. Technometrics, 14: 583-597, 1972.

6. Camp, D. C., J. A. Cooper, and J. R. Rhodes. X-Ray Fluroescence Analysis - Results of a First Round Intercomparison Study. X-Ray Spectrometry, 3: 47-50, 1974.

7. Camp, D. C., A. L. Van Lehn, J. R. Rhodes, and A. H. Pradzynski. Intercomparison of Trace Element Determinations in Simulated and Real Air Particulate Samples. X-Ray Spectrometry, 4: 123-137, 1975.

8. Stevens, R. K., T. G. Dzubay, G. Russwurm, and D. Rickel. Sampling and Analysis of Atmospheric Sufates and Related Species. Atmospheric Environment (in press), 1978.

9. Contant, R. W. Factors Affecting the Collection Efficiency of Atmospheric Sulfate. U.S. Environmental Protection Agency, Office of Research and Development Report EPA-600/2-77-076, Research Triangle Park, NC 1977.

10. Spicer, C. W., P. M. Schumacher, J. A. Kouyoumjian, and D. W. Joseph. Sampling and Analytical Methodology for Atmospheric Nitrate. U.S. Environmental Protection Agency, Office of Research and Development Report EPA-600/2-78-009, Research Triangle Park, 1978.

11. John, W., G. Reischl, S. Goren, and D. Plotkin. Anomalous Filtration of Solid Particles by Nuclepore Filters. Atmos. Environ. (To be published).

12. Dzubay, T. G., L. E. Hines, and R. K. Stevens. Particle Bounce Errors in Cascade Impactors. Atmos. Environ. 10: 229-234, 1976.

APPENDIX A

SAMPLER AND ANALYTICAL TECHNIQUE SUMMARIES

PART I
One Page Summaries

R. Burton CHAMP and High Volume Samplers 52

T. Cahill Sierra Multiday and Stacked Filter Units 54

R. Delumea TWO MASS sequential tape sampler 57

T. G. Dzubay Manual Dichotomous and Series Filter Samplers . . . 58

G. M. Hudson Linear Streaker Samplers 60

B. W. Loo Automated Dichotomous Samplers 61

P. Mueller Cyclone Sequential Filter Samplers 62

C. E. Rodes EMSL Dichotomous and High Volume Sampler 63

R. L. Tanner Diffusion and High Volume Sample 65

PART II
Descriptive Summaries

R. Burton CHAMP and High Volume Samplers 67

T. Cahill Sierra Multiday Stacked Filter Units 69

R. Delumea TWO MASS sequential tape sampler 74

T. G. Dzubay Manual Dichotomous and Series Filter Samplers . . . 76

G. M. Hudson Linear Streaker Samplers 81

B. W. Loo Automated Dichotomous Samplers 84

P. Mueller Cyclone Sequential Filter Samplers 86

C. E. Rodes EMSL Dichotomous and High Volume Sampler 90

R. L. Tanner Diffusion and High Volume Sample 92

Preceding page blank

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Robert M. Burton

INSTITUTION: U.S. EPA, Health Effects Research Laboratory

SAMPLER TYPE: CHAMP Particulate Fractionator

OPERATING CHARACTERISTICS:

FLOW RATE: 1130 ℓ/m

PARTICLE SIZE CUTPOINTS: 26 μm (upper cut-off)
3.5 μm (lower cut-off)

COLLECTION SUBSTRATE: 12-inch diameter Glass Fiber,
Gelman Type A (3.5-26 μm)
8-inch by 10-inch Glass Fiber,
Gelman Type A (0-3.5 μm)

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

1. Sierra Calibration Orifice Model 330.
2. Sierra High Volume constant Flow Controller model 310, with measured stability of .03 cubic meters/minute.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:

1. Mass (0-3.5 μm).
2. Mass (3.5-26 μm).
3. Suspended Nitrates (0-3.5 μm).
4. Suspended Sulfates (0-3.5 μm).

ANALYTICAL TECHNIQUE(S) USED:

1. Mass - (0-3.5 μm) and (3.5-26 μm) Mettler Digital Balance (.01 mg sensitivity).
2. Suspended Nitrates - (0-3.5 μm) Filter strip reflux with distilled water, copper-cadmium reduction, sulfanilamide reaction.
3. Suspended Sulfates - (0-3.5 μm) Filter strip reflux with distalled water, water soluble sulfate then measured by the methylthymol blue (MTB) method.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Robert M. Burton

INSTITUTION: U.S. EPA, Health Effects Research Laboratory

SAMPLER TYPE: CHAMP Flow Controlled High Volume Sampler

OPERATING CHARACTERISTICS:

FLOW RATE:	1130 ℓ/m
PARTICLE SIZE CUTPOINTS:	none
COLLECTION SUBSTRATE:	8-inch by 10-inch Glass Fiber, Gelman Type A

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

1. Sierra Calibration Orifice, Model 330.
2. Sierra High Volume Constant Flow Controller Model 310, with measured stability of .03 cubic meters/minute.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Total Mass
2. Total Suspended Nitrates
3. Total Suspended Sulfates

ANALYTICAL TECHNIQUE(S) USED:

1. Mass - Mettler Digital Balance (.01 mg sensitivity).
2. Suspended Nitrates - Filter strip reflux with distilled water, copper-cadmium reduction, sulfanilamide reaction.
3. Suspended Sulfates - Filter strip reflux with distilled water, water soluble sulfate then measured by the methylthymol blue (MTB) method.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Thomas A. Cahill, + Air Quality Group, Crocker Nuclear Lab.

INSTITUTION: University of California, Davis 95616

SAMPLER TYPE: Sierra Multiday Impactor

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 24 liters/min

PARTICLE SIZE CUTPOINTS:
Stage 1 - 4.3 microns - less than 20 microns*
Stage 2 - 0.78 microns - 4.3 microns
Stage 3 - 0.01 microns - 0.78 microns

COLLECTION SUBSTRATE: Mylar type S, with about 60 micrograms/cm^2 Apiezon L coatings; filter - 0.4 micron Nuclepore

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Rotometer in instrument; orifice (0.5" H_2O) on intake, (interm.) cal. by 9 litre Collins Spriometer

No flow control (early unit borrowed for test)

Mean change in flow - 5.7%; Estim. error, ± 2%

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Routinely included in output: Na,Mg,Al,Si,P,S,Cl,K,Ca,Ti,V,Cr,Mn,Fe Co,Ni,Cu,Zn,Ge,Ga,As,Se,Br,Rb,Sr,Zr,Mo,Ba,Pt,Au,Hg,Pb
2. All other elements heavier than sodium - x-ray lines recorded, with energy and intensity, for manual reduction. Second analysis with higher gain to cover Ca - Rare earths.

ANALYTICAL TECHNIQUE(S) USED:

1. PIXE - 18 MeV alphas (2 detector gains)
2. XRF - secondary fluorescers and filters

*Intake calibrated for 20 micron cut point (approximate); 60 mesh stainless steel screen added since that time has reduced the cut point.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Thomas A. Cahill, + Air Quality Group, Crocker Nuclear Lab.

INSTITUTION: University of California, Davis 95616

SAMPLER TYPE: Stacked Filter Unit

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 5 liters/min

PARTICLE SIZE CUTPOINTS: Coarse stage - 2.6 microns - less than 20 microns*
Fine stage - 0.01 microns - 2.6 microns

COLLECTION SUBSTRATE: Coarse stage - 8 micron Nuclepore Filter
Fine stage - 0.4 micron Nuclepore Filter

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Orifice meter intermittantly placed over intake, calibrated by 9 litre Collins Spirometer

Passive flow control through a 10:1 ballasting orifice at pump.

Mean change in flow - 9%; Estim. error, ± 2%

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Routinely included in output: Na,Mg,Al,Si,P,S,Cl,K,Ca,Ti,V,Cr,Mn,Fe, Co,Ni,Cu,Zn,Ge,Ga,As,Se,Br,Rb,Sr,Zr,Mo,Ba,Pt,Au,Hg,Pb
2. All other elements heavier than sodium - x-ray lines recorded, with energy and intensity, for manual reduction. Second analysis done during this test for Ca through rare earths.
3. Mass, coarse and fine

ANALYTICAL TECHNIQUE(S) USED:

1. PIXE - 18 MeV alphas (2 detector gains)
2. XRF - secondary fluorescers and filters
3. Mettler blance

*Intake calibrated for 20 micron cut point (approximate); 60 mesh stainless steel screen added since that time has reduced the cut point.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Thomas A. Cahill, + Air Quality Group, Crocker Nuclear Lab.

INSTITUTION: University of California, Davis 95616

SAMPLER TYPE: Total Filter Unit

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 24 liters/min

PARTICLE SIZE CUTPOINTS: None; intake, less than 20 microns*

COLLECTION SUBSTRATE: Gelman GA4 Filters (NOTE: Results obtained at Charleston low by 8% due to incorrect filter area used.)

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Orifice meter imtermittantly placed over intake, directly calibrated by a 9 litre Collins Spirometer

Passive flow control through a 2:1 ballasting orifice at pump.

Mean change in flow - 1%; Estim. error, ± 1%

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Routinely included in output: Na,Mg,Al,Si,P,S,Cl,K,Ca,Ti,V,Cr,Mn,Fe, Co,Ni,Cu,Zn,Ge,Ga,As,Se,Br,Rb,Sr,Zr,Mo,Ba,Pt,Au,Hg,Pb
2. All other elements heavier than sodium - x-ray lines recorded, with energy and intensity, for manual reduction. Second analysis done during this test for Ca through rare earths.
3. Mass

ANALYTICAL TECHNIQUE(S) USED:

1. PIXE - 18 MeV alphas (2 detector gains)
2. XRF - secondary fluorescers and filters
3. Mettler blance

---

*Intake calibrated for 20 micron cut point (approximate); 60 mesh stainless steel screen added since that time has reduced the cut point.

SUMMARY OF SAMPLING AND ANALYSIS METHOD

PARTICIPANT: Richard Delumyea & Ed Macias

INSTITUTION: Washington University

SAMPLER TYPE: TWOMASS two stage sequential tape sampler

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 12 to 18 ℓ/m

PARTICLE SIZE CUTPOINTS: 3.5 μm

COLLECTION SUBSTRATE: Glass fiber with celluose backing

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

See long write-up, page 74

SPECIFIC POLLUTANT SPECIES MEASURED:

Mass, Sulfur

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: T. Dzubay, et al

INSTITUTION: US EPA

SAMPLER TYPE: Two manual Dichotomous, Samplers D and R

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 14 ℓ/m

PARTICLE SIZE CUTPOINTS: 3.5 μm (14 μm upper cut-off)

COLLECTION SUBSTRATE: Sampler D: asymmetric teflon (1-10 μm)
Sampler R: 1 μm (FALP) Fluoropore

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Sampler D: Differential pressure regulator on pump exhaust

Sampler R: Sierra Series 250 servo system

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

Sampler D: mass and all elements detected by XRF

Sampler R: mass, SO_4, NO_3, S, Pb, and other trace elements detected by XRF

ANALYTICAL TECHNIQUE(S) USED:

Gravimetric, XRF, Ion chromatograph

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: T. Dzubay, et al

INSTITUTION: US EPA

SAMPLER TYPE: Two Tandem Filter Samplers, M and N

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 7.2 ℓ/m

PARTICLE SIZE CUTPOINTS: 3.5 μm

COLLECTION SUBSTRATE: Sampler M: 9.6 μm Nucleopore (coarse)/
0.4 μm Nucleopore (fine
Sampler N: 9.6 μm Nucleopore (coarse)/
Assymetric Teflon (fine

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Sierra flow servo system

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

All elements detected by XRF

ANALYTICAL TECHNIQUE(S) USED:

XRF

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: G. Martin Hudson, Physics Department
Alistair C. D. Leslie, Oceanography Department

INSTITUTION: Florida State University

SAMPLER TYPE: Linear Streaker Samplers

OPERATING CHARACTERISTICS:

	Streaker #1	Streaker #2
FLOW RATE (in liters/m):	0.5 ℓ/m	0.35 ℓ/m
PARTICLE SIZE CUTPOINTS:	Total filter	Total filter
COLLECTION SUBSTRATE:	0.4 μ nuclepore	0.2 μ nuclepore

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Calibrated TYLAN model FC 260 Mass Flow Controllers. Field checks made with rotometers.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

Particulate, elemental: Al, Si, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ge, As, Se, Br, Rb, Sr, Mo, Ag, Cd, Sn, Sb, I, Cs, Ce, Au, Hg, Pb, Bi

ANALYTICAL TECHNIQUE(S) USED:

PIXE (proton induce x-ray emission) calibrated to commercially prepared standards good to ± 5%.

SUMMARY OF SAMPLING AND ANALYSIS METHOD

PARTICIPANT: Billy W. Loo

INSTITUTION: Lawrence Berkeley Lab, Univ. of California

SAMPLER TYPE: 3 Automated Dichotomous Air Samplers: C, L, and S

OPERATING CHARACTERISTICS:

SAMPLING FLOW RATE:	50 ℓ/m
PARTICLE SIZE CUTPOINTS:	2.4 μm
COLLECTION SUBSTRATE:	0.1μm pore size teflon membrane filter mounted on 5 x 5 cm plastic frames

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

The Dwyer RMC-103-SSV and Metheson #603 rotometers were used for field calibration. They were cross-checked with laboratory dry and wet test meters.

An automated flow controller consisting of pressure sensors and water driven micrometer valves maintains the flow to within 1% of present values.

SPECIFIC POLLUTANT SPECIES MEASURED:

Total mass, Si, S, Ca, Ti, Fe
Cu, Zn, Se, Br, and Pb

ANALYTICAL TECHNIQUE(S) USED:

Beta gauge, Energy dispersion x-ray fluorescence analysis, secondary exciters.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Peter K. Mueller

INSTITUTION: Environmental Research & Technology, Inc.

SAMPLER TYPE: Sequential Filter Samplers: E and F

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 100 ℓ/m

PARTICLE SIZE CUTPOINTS: Sampler E: About 15 m at inlet

Sampler F: 2.5 μm

COLLECTION SUBSTRATE: 47 mm dia. Teflon-coated glass fiber, (Pallfelx TX40HI20)

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Calibrated orifice used for field calibration.

Flow monitored by continuous chart recording of vacuum upstream pump.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

Total mass, SO_4, NO_3

Small mass, SO_4, NO_3

ANALYTICAL TECHNIQUE(S) USED:

Mass: Gravimetry

SO_4, NO_3: Ion chromatography

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Charles E. Rodes

INSTITUTION: EPA/EMSL

SAMPLER TYPE: EMSL Dichotomous

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 14 ℓ/min

PARTICLE SIZE CUTPOINTS: Inlet 20 μm, cutpoint 3.5 μm

COLLECTION SUBSTRATE: Fluropore 37 mm

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Flow Calibration using mass flow meters.

Flow maintained by restrictor valves.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

TSP, Pb, $SO_4^=$

ANALYTICAL TECHNIQUE(S) USED:

TSP	gravimetric
Pb	Atomic Absorption (flameless)
$SO_4^=$	Ion Chromatograph

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Charles E. Rodes

INSTITUTION: EPA/EMSL

SAMPLER TYPE: Hi-Vol

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 1415 ℓ/m

PARTICLE SIZE CUTPOINTS: "Total Suspended Particulates" (TSP)

COLLECTION SUBSTRATE: Glass Fiber 8 x 10 inch

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Flow Calibration using orifice meter.

Flow maintained by mass flow controller.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

TSP, Pb, $SO_4^=$

ANALYTICAL TECHNIQUE(S) USED:

TSP: gravimetric

Pb: Atomic Absorption

$SO_4^=$: Methyl Thymol Blue

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Roger L. Tanner, Leonard Newman

INSTITUTION: Brookhaven National Laboratory

SAMPLER TYPE: Diffusion Sampler

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): DBO: 10.6 ℓ/min; DB1: 16.8 ℓ/m
DB2: 13.8 ℓ/min.

PARTICLE SIZE CUTPOINTS: DBO: 0 to ca 5 μm; DB1: 0.03 μm to ca 5 μm;
DB2: 0.12 μm to ca 5 μm.

COLLECTION SUBSTRATE: Phosphoric acid-treated Pallflex GAO tissue quartz.

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Flows were calibrated with open Matheson rotometer tubes in series with and upstream from the 47 mm filter holders. The flow variations in calibrations before and after the Intercomparison averaged 11% for the 3 sample sets.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Sulfate
2. Nitrate
3. Strong acid
4. Ammonium
5. Sulfuric acid

ANALYTICAL TECHNIQUE(S) USED:

1. Extraction into pH 4 aqueous solution and determination by ion chromatogrphy.
2. Hydrazine reduction and colorimetry.
3. Gran titration with correction for pH 4 leach solution.
4. Indophenol colorimetry.
5. Benzaldehyde extraction and determination by flash volatilization-FPD or by ion chromatography.

SAMPLING AND ANALYSIS METHOD SUMMARY

PARTICIPANT: Roger L. Tanner, Leonard Newman

INSTITUTION: Brookhaven National Laboratory

SAMPLER TYPE: Staplex HiVol with 5-in circular filter pack in conventional HiVol enclosure.

OPERATING CHARACTERISTICS:

FLOW RATE (in liters/m): 700 ℓ/m

PARTICLE SIZE CUTPOINTS: 0 to ca 20 μm

COLLECTION SUBSTRATE: Phosphoric acid-treated Pallflex GAO tissue quartz for aerosol collection. K_2CO_3, glycerol-impregnated cellulose (S & S 2W, 2 sheets) for SO_2 collection.

METHOD OF FLOW CALIBRATION AND MAINTENANCE:

Magnetohelic gauge measured with filter pack in place with unexposed filters; checked for repeatability with representative exposed filter packs after study. The average reduction in flow during sampling was 1.1 m^3/hr (3%) with average flow used for concentration calculations.

ALL SPECIFIC POLLUTANT SPECIES MEASURED:
(including those not intercompared)

1. Sulfur dioxide
2. Sulfate
3. Nitrate
4. Strong acid
5. Ammonium
6. Sulfuric acid

ANALYTICAL TECHNIQUE(S) USED:

1. Filter pack, extraction into peroxide solution, determination as sulfate by trubidimetry or ion chromatography.
1. Extraction into pH 4 aqueous solution and determination by ion chromatogrphy, or extraction into 10^{-2}N HCl with determination by Methylthymol Blue colorimetry.
2. Hydrazine reduction and colorimetry.
3. Gran titration with correction for pH 4 leach solution.
4. Indophenol colorimetry.
5. Benzaldehyde extraction and determination by flash volatilization-FPD or ion chromatography.

CHAMP AND HIGH VOLUME SAMPLERS

Robert Burton
Health Effects Research Laboratory
Environmental Protection Agency
Research Triangle Park, NC 27711

EQUIPMENT DESCRIPTION

Two CHAMP RSP samplers and one flow-controlled high volume sampler were sent to Charleston, W. Va., to participate in an intercomparison study of particulate analyzers. The CHAMP RSP sampler divides the particulate matter into two collected groups, 3.5 - 26 microns and 0 - 3.5 microns.

Particles greater than 26 microns in diameter are excluded by the aerodynamic construction of the analyzer. Particulate matter in the 3.5 to 26 micron region is impacted on a 12-inch diameter filter utilizing a single stage Andersen impactor plate. Particles smaller than 3.5 microns are collected on a standard 8 X 10 inch hi volume filter. The Andersen impactor is adapted to fit between the after filter and the base section of the fractionator itself. All filter media are of glass fiber construction.

The third sampler was a standard hi volume sampler, which collects all particulate matter smaller than 100 microns. All samplers used Sierra Flow controllers operating on General Metal's Model 2000H motor assemblies to maintain a constant 1.13 m^3/min (40 cfm) flow. The hi volume sampler is described in detail in Volume 36, No. 228 of the Federal Register.

SAMPLER CALIBRATION

All devices were calibrated using a standard sierra orifice calibrated at the factory and verified by our laboratory Rootsmeter. The calibration curve of the orifice is: $Q = 1.4054\ (\Delta P)^{1/2}$ where ΔP is the pressure difference in inches of water as measured across the orifice. Q is then corrected using the following equation to 760 mm Hg and 25°C (298°K):

$Q_s = (Pa/Ta)^{1/2}\ (3.156)Q$ where Q_s is the standard flow,
Pa is the barometric pressure in mm HG, and
Ta is the ambient temperature in degrees Kelvin.

The orifice was placed on top of the Andersen head without the RSP top hat and a calibration curve was drawn using clean filters for the Andersen and hi volume heads which are assembled in series. Various flows were obtained by changing the speed of the hi vol motor with a variac to simulate different loadings on the filters. A curve was obtained for each sampler. For field operations a small rotameter was attached to the bottom of each hi vol and calibrated simultaneously with the orifice. The rotameters facilitated taking field flow measurement, although both rotameter and orifice readings were recorded for this study. After the response equations were determined for each device the flow controllers were then set to obtain 1.13 m^3/min (40 cfm) flow. The flow obtained during the study show little variation from this 1.13 setting, varying only from 1.17 to 1.11 m^3/min. Keep in mind, however, that only stop and start flows were recorded during operation and actual flows during sampling may vary but should have been kept within the above tolerances with properly operating flow controllers.

ANALYSIS

The glass fiber filters were conditioned at 40% relative humidity and 25°C for 24 hours. They were then numbered and weighed to the nearest 0.1 mg. Upon return from the field they were again equilibrated at the previous conditions and weighed. Total suspended particulate (TSP) and respirable suspended particulate (RSP) were then determined for the appropriate samplers. The weight of the collected particulate matter was divided by the total volume of air sampled to obtain TSP and RSP concentrations in $\mu g/m^3$. The sample volumes were calculated using the following equation:

$$V = \frac{Qi + Qf}{2} T$$

where Qi = initial flow - m^3/min
Qf = final flow - m^3/min
T = total sampling time - min
V = air volume - m^3

After the particulate concentrations were determined, the filters were then sent to Stewart Laboratories in Knoxville, Tenn. for $SO_4^=$ and NO_3^- analysis. The $SO_4^=$ analysis was performed using the methylthymol blue (MTB) method while the NO_3^- analysis utilized a copper-cadmium reduction column and NEDA dye. The concentrations were expressed as $\mu g/m^3$ of each ion.

Our program does not routinely analyze for lead. For specific lead samples, Tom Dzubay would perform our lead analysis. Since his section also participated in this study, no lead analyses were performed on these filters.

Further detailed explanation of these methods can be found in EPA publication 600/1-76-011, Community Health Environmental Surveillance Studies Air Pollution Monitoring Handbook: Manual Methods.

SIERRA MULTIDAY AND STACKED FILTER UNITS

T. A. Cahill
Crocker Nuclear Laboratory and the Department of Physics
University of California, Davis, CA 95616

The Davis Air Quality Group, working in conjunction with the California Air Resources Board, the Research Applied to the National Needs Division of the National Science Foundation, and the U.S. Energy Research and Development Agency, had developed and modified techniques for collecting and analyzing atmosperic particulates. Monitoring of aerosols in California (1) by size and elemental composition for the California Air Resources Board (CARB), began in January, 1973, using a Lundgren-type rotating drum impactor (2), modified for this program, and since marketed as the Environmental Research Corporation, and later, Sierra Instruments Corporation, Multiday Impactor. Quantitative operation of this device was achieved through use of quasi-monolayer depositions on coated surfaces in the two impaction stages, and non-hygroscopic, surface-deposition filter media for the backup filter. Normal integration period was 24 hours. Approximately 5000 station-days of data in three size fractions, 20 μm to 3.6 μm, 3.6 μm to 0.65 μm, and 0.65 to 0.01 μm, have been accumulated in this program. The major aims of the program are in characterization of aerosol components, the identification of aerosol sources, study of transport, transformations, and sinks, identification of sources of gaseous pollutants measured by the ARB monitoring network, and effects of aerosols and gases upon visibility.

Elemental analysis of samples collected in this program occurs after transport of samples to Davis, with contamination and loss effects summarized in the Table. Analysis occurs primarily via particle induced x-ray emission (PIXE) (3,4) with significant support through energy-dispersive x-ray fluorescence (XRF) and ion scattering analysis (ISA). Smaller numbers of analyses are done using a scanning electron microscope and an electron microprobe with wave-length-dispersive XRF capabilities. Total number of elemental values to date in the monitoring program exceed 500,000. The system has participated in numerous interlaboratory comparisons (5), in addition to a massive (6000 analyses/year) internal program of analytical validation.

The need to perform diurnal and spatial profiles that have some size information and full gravimetric and elemental analysis compatibility has led to development of low cost, portable stacked filter units (SFU's) (6) following a suggestion of K. R. Spurney et al.(7) These units are designed to deliver a quasi-respirable separation of aerosols, with a 50% cut point and shape as close as possible to that occurring between the nasal-pharangeal and tracheopulmonary compartments of the human respiratory tract. Evaluations of this device are given in the SFU table for a two stage device designed to operate at 5 ℓ/min.

In an attempt to upgrade the information delivered by the large number of Hi-Vol samplers operated by state and local agencies in California, the SFU has been evaluated as a continuous monitoring device. The SFU would operate on a 7 day integration period, avoiding the statistical problems inherent in a 1 day in 6 Hi-Vol mode, while delivering respirable and non-respirable size cuts in samples suitable for gravimetric and full elemental analysis. Lower flows are used, 2 ℓ/min, and on occasion, especially when visibility problems exist, a third stage is added to mimic the cut points of the multiday.

For the sampler intercomparison study, a Multiday impactor and a stacked filter unit will be used. The impactor will use 0.6 mg/cm^2 mylar, coated with 0.065 mg/cm^2 Apiezon type L grease, as impaction surfaces, and 0.4 micron Nuclepore filter for the afterfilter. The stacked filter unit will use 8 micron and 0.4 micron filters. Flow for both units will be set by a spirometer-calibrated orifice meter on the intake. Analysis will be by both PIXE and XRF, with elements aluminum and heavier quoted either as observed values or upper limits of elements not observed. Calibration of the analysis systems will be via gravimetric thin element standards, and total accuracy will be within ± 10% absolute when statistical precision is adequate.

REFERENCES

1. R. G. Flocchini, T. A. Cahill, D. J. Shadoan, S. J. Lange, R. A. Eldred, P. J. Feeney, G. W. Wolfe, D. C. Simmeroth, J. K. Suder, Env. Sci. and Techn. 10, 76 (1976).

2. D. A. Lundgren, J. Air Poll. Contr. Assoc. 17, 4 (1976).

3. S. A. E. Johansson and T. B. Johansson, Nucl. Instr. and Meth. 137, 473 (1976).

4. T. A. Cahill, in "New Uses of Ion Accelerators," J. Ziegler, Editor, Plenum Press, New York (1975).

5. D. C. Camp, A. L. Van Lehn, J. R. Rhodes, A. H. Pradzynski, J. X-Ray Spectr. 4, 123 (1975); PIXE, Group # 15; SRF, Group # 4.

6. T. A. Cahill, L. L. Ashbaugh, J. B. Barone, R. A. Eldred, P. J. Feeney, R. G. Flocchini, C. Goodart, D. J. Shadoan, and G. W. Wolfe, "Analysis of Respirable Fractions in Atmospheric Particulates via Sequential Filtration," J. Air Pol. Contr. Assoc. 27, 675 (1977).

7. K. R. Spurney, J. P. Lodge, Jr., E. R. Frank, and D. C. Sheesley, Env. Sci. and Techn. 3, 464 (1969).

Summary of Sample Collection Evaluations

MULTIDAY IMPACTOR

1. Large particle cut-off (50%) (intake)	D_p = 20 μm, variable w. wind speed*
2. First stage cut-off (50%)	D_p = 4.3 μm, ±0.4 μm
3. Second stage cut-off (50%)	D_p = 0.78 μm, ±0.05 μm
4. Impaction collection efficiency	(97±3)%
5. Filter capture efficiency	
a) laboratory aerosols	(96±2)%
b) ambient aerosols	(99±3)%
6. Sizing errors due to non-optimum ollection	
a) coarse collected on filter (soils)	< 1%
b) fine collected on coarse (Pb, S aerosols)	< 1%
7. Summary of sizing:	Stage 1 (coarse) < 20 μm to 4.3 μm Stage 2 (intermediate) 4.3 μm to 0.78 μm Stage 3 (fine) 0.78 μm to 0.01 μm
8. Flow calibration	Rotometer - continuous Orifice and meter on Intake (0 to 1" H_2O (Intermittent; Spirometer calibrated)
9. Total unit efficiency (fine particles)	(93±3)% (4 X 5a) [correction not applied to the Charleston data]

Summary of Sample Transport and Handling Corrections

1. Contamination in Handling	$\gtrsim$ 15 ng/m^3 Si, < 10 ng/m^3 Al, K; 6 ng/m^3 others < 2% of Si value at most locations less for other elements
2. Loss of particles during transport	< 2%
3. Loss of material during storage	<< 10%

*Addition of a 60 mesh screen has lowered this cut.

Summary of Sample Collection Evaluations

U.C. Davis Stacked Filter Unit at 5 l/min (2 stage)

1. Large particle cut-off (50%) (intake)	D_p = 20 μm, variable w. wind speed*
2. Coarse stage cut-off (50%)	D_p = 2.6 μm ± 0.5 μm, quasi-respirable shape
3. Filter collection efficiency	
a) laboratory aerosols	(96±2)%
b) ambient aerosols	(99±3)%
4. Sizing errors due to non-optimum collection	
a) coarse particulates on fine stage (soils)	< 6%
b) fine particulates on coarse stage (Pb, idling auto)	< 2.5%
5. Summary of sizing:	Coarse < 20 μm to 2.6 μm Fine 2.6 μm to 0.01 μm Shape quasi-respirable, 20 l/min nasopharynx
6. Flow calibration	Orifice and meter on Intake (0 to 1" H_2O (Intermittent; Spirometer calibrated)
7. Total unit efficiency	(96±2)% (4a) [correction not applied to the Charleston test]

Summary of Sample Transport and Handling Corrections

1. Contamination in Handling	$\gtrsim$15 ng/m^3 Si, < 10 ng/m^3 Al, K; < 6 ng/m^3 others < 2% of Si value at most locations less for other elements
2. Loss of particles during transport	< 2%
3. Loss of material during storage	$\ll$ 10%

---

*Addition of a 60 mesh screen has lowered this cut.

Summary of Analytical Corrections and Uncertainties

1. Statistical uncertainty in peak counts - variable
2. Uncertainty in gravimetric standards - ± 5%
3. Integration of Ion beam - ± 2%
4. Ion beam attenuation - < 5%
5. Electronic corrections, accuracy - ± 5%
6. Peak integration and background uncertainties - ± 7%, (variable)
   Thus, reproducibility - ± 5%
   system uncertainty - ±10%
7. Loss of volatile elements (beam + vacuum) - < 5%
8. Particle Size Corrections

	Stage #1	Stage #2	Filter Stage
Na	2.49	1.32	<10%
Mg	1.96	1.22	"
Al	1.68	1.16	"
Si	1.49	1.12	"
P	1.37	1.09	"
S	1.26	1.07	"
Cl	1.31	<10%	"
K	1.12	<10%	"
others	<10%	<10%	"

9. Loading Corrections (for 120 $\mu g/m^3$ aerosol)

	Stage #1	Stage #2	Filter Stage
Na	<10%	1.70	1.22
Mg	"	1.39	1.11
Al	"	1.23	1.07
Si	"	1.14	1.04
others	"	<10%	<10%

Uncertainty in particle size and loading corrections are estimated at ± 20% for most ambient aerosols, although, especially for the particle size corrections, worse cases are common. These corrections thus increase the total error for the four lightest elements.

REFERENCE
(Sierra Multiday)

"Monitoring California's Aerosols by Size and Elemental Composition", R. G. Flocchini, T. A. Cahill, D. J. Shadoan, S. J. Lange, R. A. Eldred, P. J. Feeney, G. W. Wolfe, D. C. Simmeroth, and J. K. Suder, Env. Sci. and Technology 10, 76 (1976).

REFERENCE
(Stacked Filter Units)

"Analysis of Respirable Fractions in Atmospheric Particulates via Sequential Filtration", T. A. Cahill, L. L. Ashbaugh, J. B. Barone, R. A. Eldred, P. J. Feeney, R. G. Flocchini, C. Goodart, D. J. Shadoan, and G. W. Wolfe, J. Air Pollution Control Assoc. 27, 675 (1977)

TWO MASS SAMPLER

R. Del Delumyea and Edward S. Macias
Department of Chemistry
Washington University
St. Louis, Missouri 63130

INTRODUCTION

As part of an EPA/DOE sponsored Sampler Intercomparison Field Study, TWOMASS tape samplers were installed on the roof of the Federal Building in downtown Charleston, West Virginia and run from May 11 through May 19, 1977. One TWOMASS sampler collected 6 hr samples at a nominal flow rate of 12 ℓpm and another collected 3 hr samples at a nominal flow rate of 18 ℓpm. The 3 hr sampler was equipped with a beta-attenuation mass monitor system which provided a continuous record of coarse (>3.5 μm) and fine (<3.5 μm) particle concentration.

The purpose of the study was to compare results obtained from various sampling and analytical procedures. The sulfur content of the samples was determined by flash vaporization followed by flame photometric detection (FV-FPD). The sampling system was designed for high time resolution (30-120 min). For this study three hour samples were collected. Since the reporting time for all intercomparison data was set at 12 hour intervals, four 3-hr samples were added to give the required information. In cases where one 3-hr sample was not available, the remaining three were averages. If more than one sample was missing during a twelve hour period, no results were reported.

ANALYTICAL METHODS AND PROCEDURES

Sampler

Atomospheric aerosol samples were collected in two size ranges with a TWOMASS automated two-stage sequential filter sampler. The flow system separated particles into two size fractions. Coarse particles (diam > 3 μm) were impacted on a glass fiber filter with cellulose backing. Fine particles were collected on the same type of high efficiency-low mass density filter. The flow rate through the TWO MASS was set at 12 or 18 ℓ/min using a GAST rotary vane pump.

Beta Attenuation Mass Monitor

Both the impaction and filtration heads of one TWOMASS were fitted with independent sources (Carbon-14) and detector systems (solid state ruggedized silicon surface-barrier type). After electronic amplification and filtration the output signals were sent through counters to a programmable calculator. Mass was calculated using the equation

$$\Delta M = \frac{A}{\Delta t f \mu_m} \ln (I_o/I)$$

where ΔM is the mass concentration, A the spot area, f is the flow rate, μ_m the mass attenuation coefficient, t the time counting interval, I_o the count rate of the previous interval and I the count rate of the current interval. The beta intensity transmitted through the filter paper was measured as the particulates were being deposited; mass concentrations were obtained at the end of each 10-min counting period. Tapes were automatically advanced at three hour intervals.

Particulate Sulfur Analysis

Water soluble particulate sulfur in the fine particle samples from the TWOMASS instrument was determined using a flash vaporization-flame photometric detection method. The sulfur analyzing system consisted of a flash vaporization vessel, flame photometric detector (Meloy SA-160), electronic integrator, and a strip chart recorded. The sample vaporization was performed by capacitor discharge across a tungsten boat, resulting in resistance heating to 1100°C. Vaporized gaseous decomposition products of sulfur compounds were carried to the flame photometric detector by a stream of clean, charcoal filtered air at a flow rate of 2 cm^3/sec. The linearized output was registered on the strip chart recorder and the peak area integrated by an electronic integrator.

To the filter deposits, 0.5 to 1 ml double distilled deionized water was added and utrasonically disintegrated at 25°C for 10 minutes. Sample standard solutions were transferred with a 5 $\mu\ell$ microsyringe to the tungsten boat and heated at 60°C for 30 seconds until dry. The residue was then vaporized by capacitor discharge.

This technique was calibrated using solutions of sulfuric acid, ammonium sulfate and bisulfate, zinc- and zinc-ammonium sulfate in the range 0.16-34 μg/ml of sulfur. [Husar et al, Anal. Chem., 47, 2062 (1975)]. A 5 $\mu\ell$ sample of distilled deionized water gave a signal equivalent to 0.3 ± 0.05 ng sulfur, corresponding to a solution concentration of 0.06 μg/ml. This value was a factor of five lower than the measured sulfur content of filter blank extract.

MANUAL DICHOTOMOUS AND SERIES FILTER RESPIRABLE SAMPLERS

T. G. Dzubay, R. K. Stevens, and L. A. Hines
Atmospheric Instrumentation Branch
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

G. M. Russwurm and D. G. Rickel
Northrop Services, Inc.
Research Triangle Park, N.C. 27709

AEROSOL SAMPLING DEVICES

For our participation in the sampler intercomparison conducted in Charleston, West Virginia between May 11 and May 19, 1977, four size fractionating aerosol samplers were used. Two were manual dichotomous samplers (1) (MDS-S and MDS-A), and two were tandem filter respirable samplers (2) (TF-M and TF-P). Table 1 summarizes the characteristics of each sampler and the filter media that were used.

The manual dichotomous samplers use a virtual impactor designed to separately collect fine and coarse particles with a 50% separation diameter occurring at 3.5 µm. The upper 50% cutoff occurs at 14 µm and is due partly to losses in the virtual impactor but is mainly due to the use of a sampling inlet designed to sample particles with an efficiency that is independent of wind speed and also to reject giant, nonrespirable particles.(3)

The tandem filter sampler consists of a large pore sized Nuclepore filter followed by a highly efficient filter. This sampler seprately collects the coarse and fine particle fractions on the two filters.(2,4,5) For the flow rates and filters shown in Table 1, the cutpoint occurs at 3.5 µm for liquid particles.(2,4) Although there are no particle losses for this fractionator, the size separation is not quantitative because of tendency for dry, solid particles to bounce through the first filter.(6) The upper 50% cutoff of the inlet is estimated to occur at about 20 µm.

Flow rates were checked using a Sierra Model 541* portable mass flow meter at the beginning and end of each sampling interval. Such measurements were made while the samplers were running and required about one minute per sampler. The calibration of the protable flow meter was checked daily against a dry test meter at flow rates of 6 and 14 liters per minute. After the first 4 days of sampling the jets in the virtual impactor were inspected and cleaned.

---

*Mention of commercial products or company names does not constitute endorsement by the U.S. Environmental Protection Agency.

CALCULATION OF CONCENTRATIONS

In determining the sampled volumes, the mean of the initial and final flow rates was used. Samples were rejected if the final flow rates differed by more than 15% from the nominal values indicated in Table 1. (See page 78.)

For each dichotomous sampler there is a small flow of air through the coarse particle filter, and a proportionally small amount of fine particle mass is collected on the coarse particle filter. To correct for this effect, particle concentrations in the two size ranges were determined from the equations:

$$C_f = M_f/(tF_f)$$

$$C_c = [M_c-(M_fF_c/F_f)]/[t(F_f + F_c)].$$

where C_f and C_c = the atmopheric concentrations of the fine and coarse particle fractions, respectively in µg/m^3

M_f and M_c = the masses collected on the fine and coarse particle filters, respectively in µg

F_f and F_c = the flow rates through the fine and coarse particle filters, respectively in m^3/min

t = the sampling time in minutes.

MASS ANALYSIS

The masses of the aerosol deposits were determined gravimetrically using a Perkin Elmer Ad-2 electrobalance that was located in the laboratory at Research Triangle Park, N.C. The electrobalance was operated on the 100 mg scale, and the weighing precision was 10 µg. At the beginning of each daily series of weighings, the span of the electrobalance was adjusted for correct response to a standard 100 mg weight. The zero of the electrobalance was checked before the weighing of each filter and was adjusted whenever a nonzero reading occurred. To eliminate any electrostatic charges on the filters, they were held for a few seconds within 1 cm of a ^{210}Po radioactive source (500 µCi) before weighing. A second similar radioactive source was positioned inside the balance enclosure. The relative humidity in the balance room was between 35 and 45% for all weighings. To equilibrate the filters after sampling, the petri dishes containing the filters were stored in the balance room for a least 24 hours with the covers partly open.

ELEMENTAL ANALYSIS

Elemental analysis of samples by x-ray fluorescence spectroscopy was carried out with an energy dispersive unit.(7) The detector is a Si(Li) diode with a resolution of 208 eV for Mn-55 K x-rays. This spectrometer (a pulsed x-ray tube design) excites the sample by characteristic x-rays from a selected set of secondary fluorescers. Elements with atomic numbers 13 through 20 are

TABLE A.1. SAMPLER AND FILTER MEDIA DESCRIPTIONS USED IN THE INTERCOMPARISON STUDY.

Sampler Type	Description	Upper 50% cutoff dia.	Flow rate l/min.	Deposit Area cm^2	Filter Media
Dichotomous (MDS-S)	Two stage virtual impactor having 50% cut point at 3.5 µm. The flow rates through the fine and coarse filters is 13.6 and 0.4 liters/min respectively and is maintained using a Sierra Series 250 mass flow sensor and pump servosystem.	14 µm measured	14	6.7	Teflon membrane having 1µm pores bonded to a polyethylene net (FALP Fluoropore from Millipore Corp.)
Dichotomous (MDS-A)	Same as MDS-S except that the constant flow rate is maintained using a constant differential pressure controller on the pump exhaust.	14 µm measured	14	6.7	Teflon membrane having assymetric pores (1µm/10 µm) oriented so that particles are collected on the 1 µm side (P137PL25 Ghia Corp.)
Tandem Filter (TF-M)	Two filters operated in series with a sampling velocity of 15 cm/sec. maintained using a Sierra (Kurtz) servosystem.	20 µm estimated	7.2	8.0	Coarse: Nuclepore having 9.6 µm dia. pores (N137PE2 Ghia Corp.) Fine: Nuclepore having 0.4µm dia. pores (N040 Poly 101 Ghia Corp.)
Tandem Filter (TF-P)	Same as TF-M	20 µm estimated	5.9	6.7	Coarse: 9.6 µm Nuclepore (N137-PE1, Ghia Corp.) Fine: Teflon, same as used for sampler MDS-A above.

analyzed using a titanium fluorescer; elements with atomic number between 22 and 38 plus Pb and Hg are analyzed using a molybenum fluorescer; elements Cd, Sn, Sb and Ba are analyzed with a samarium fluorescer.

Spectral analysis was carried out with a linear least squares fitting program which uses a library of single element spectra as the fitting functions. These spectra were acquired by the spectrometer under analysis conditions. A blank filter spectrum is used for the background and is included in the library.(8) The spectrometer is calibrated for copper and sulfur using a well characterized thin copper film standard and thin laboratory generated deposits of 0.3 μm copper sulfate particles.(8) Evaporated metal film standards obtained from Micromatter Co. (Seattle, Washington) were used for lead and other elements.(8)

To correct for attenuation of sulfur x-rays in the fine particle fraction, a very slight correction (1 to 10%) was made in proportion to the amount of mass collected.(8) For the coarse particle fraction, the attenuation correction factors for Si, S, K, Ti, Fe, Cu, Zn, Se, Br, and Pb, used were 0.48, 0.78, 0.87, 0.94, 0.94, 0.95, 0.98, 0.99, and 1.00 respectively.(9) Descriptions of the analysis procedure are described in more detail by Stevens et al.(8)

ANALYSIS OF IONIC SPECIES

The samples from MDS-S were analyzed for sulfate and nitrate using ion exchange chromatography. Extraction, the initial step in the analysis was accomplished by placing each sample in a Nalgene polypropylene bottle (30 ml volume) containing 20 ml of 5 x 10^{-5}N perchloric acid extraction solution. The extraction vessel was capped and put in a sonic bath for 20 minutes. A study using x-ray fluorescence techniques has shown this procedure extracts 99% of the sulfur from the fine fraction and 95% of the sulfur from the coarse fraction.

After extraction, sulfate and nitrate were determined using a Dionex Model 14 Ion Chromatograph (IC). The samples were spiked with a base (.003M $NaHCO_3$ + 0.0005M Na_2CO_3) so that the range 10^{-3}M to 10^{-5}M was spanned. Retention times and peak areas were obtained using standards (10^{-7} to 10^{-4} M of $(NH_4)_2SO_4$ and $NaNO_3$), and a calibration curve was drawn. Analysis of sulfate data showed that the minimum detectable level was 10^{-1} neq/ml and that sulfate concentrations were determined to within ± 10%.

The minimum detectable level for nitrate was 5 x 10^{-2} neq/ml, and the concentrations were determined to within ± 155. For the 12 hour samples collected with a 14 l/min flow rate, the detection limits expressed in units of atmospheric concentrations were 10^{-2} μg/m^3 and 7 x 10^{-3} μg/m^3 for sulfate and nitrate, respectively. A more detailed description of the extraction and analysis procedures is given by Stevens et al.(8)

REFERENCES

1. Dzubay, T. G., Stevens, R. K., and Petersen, C. M. (1977), Application of the dichotomous sampler to the characterization of ambient aerosols. X-ray Fluroescence Analysis of Environmental Samples. Ann Arbor Sci. Pub. Inc., Ann Arbor, MI 95-105.

2. Parker, R. D., Buzzard, G. H., Dzubay, T. G., and Bell, J. P. (1977), A two stage respirable sampler using Nuclepore filters in series. Atmos. Environ. 11, 617-621.

3. McFarland, A. R., Wedding, J. B., and Cermak, J. E. (1977), Wind tunnel evaluation of a modified Andersen sampler and an all weather sampler inlet. Atmos. Environ. 11, 535-539.

4. Parker, R. D., and Buzzard, G. H. (1978), A filtration model for large pore nuclepore filters. Aerosol Science 9 (to be published).

5. Cahill, T. A., Ashbough, L. L., Barone, J. B., Eldred, R. A., Feeney, P. J., Flocchini, R. G., Goodart, C., Shadoan, D. J., Wolfe, G. W. (1977), Analysis of respirable fractions in atmospheric particulates via sequential filtration. J. Air Poll. Cont. Assoc. 27, 675-678.

6. John, W., Reischl, G., Goren, S., and Plotkin, D. (1978), Anomolous filtration of solid particles by Nuclepore filters. Atmos. Environ. (to be published).

7. Jaklevic, J. M., Loo, B. W., and Goulding, F. S. (1977), Photon induced x-ray fluorescence analysis using energy dispersive detector and dichotomous sampler. X-ray Fluorescence Analysis of Environmental Samples. Ann Arbor Science, Ann Arbor, MI 3-18.

8. Stevens, R. K., Dzubay, T. G., Russwurm, G., and Rickel, D. (1978), Sampling and analysis of atmospheric sulfates and related species. Atmos. Environ. (to be published in January 1978).

9. Dzubay, T. G., and Nelson, R. O. (1975), Self absorption corrections for x-ray fluorescence analysis of aerosols. Advances in X-ray Analysis 18, 619-631.

LINEAR STREAKER SAMPLERS

G. M. Hudson, A. C. D. Leslie, H. Kaufman and J. W. Nelson

PHYSICS AND OCEANOGRAPHY DEPARTMENTS
Florida State University
Tallahassee, FL 32306

LINEAR STREAKER SAMPLERS

The Florida State Elemental Analysis Group working with the Environmental Protection Agency, the National Science Foundation, the Florida Sulfur Oxide Study Board, and numerous international groups in Europe, Asia, Africa, and South America has developed a complete air particulate monitoring system. The heart of this system is the linear streaker.(1)

During the Charleston study four streakers were deployed, but data were reported for only two of the samplers. These devices filter continuously collecting particulate over a small area of 2 mm x 5 mm. An orifice is moved by a synchronous motor-screw drive across the filter surface at a rate of 1 mm per hour to produce a 5 mm wide, 168 mm long strip sample in a time of one week. Analysis of the filter is limited to a width of 2 mm which yields pollutant data equivalent to 84 time averaged 2 hour samples. For the purpose of the intercomparison study 6 two hour samples were averaged to give the 12 hour samples reported. Polycarbonate nuclepore filters of 0.4 µm and 0.2 µm pore size were used depending on the flow rate desired. The Nuclepore filter itself may be used to limit the flow, or a flow control device may be connected in series. Flows of one liter per minute or less produce satisfactory loadings for PIXE analysis of elements $Z \geq 13$. Regularly measured are Al, Si, S, Cl, K, Ca, Fe, Zn, Br, and Pb; and less often Ti, V, Cu, Ni, Sn and As. The streaker samples are also well suited for PESA(2) (proton elastic scattering analysis) which gives trace element information in the range $1 \leq Z \leq 20$.

The streaker is a simple reliable, and flexible sampler, which is also highly portable and inexpensive. This has led to its reliable use in the Amazon basin, in the Namib desert, and in the Indian Ocean. Over 100,000 elemental data points have been generated in one year with a time resolution needed to compare with meteorological data. The linear streaker is a total filter device. Its main disadvantage is that it does not give two size fractions. This will be remedied by the circular streaker(3) which will soon be network tested. The linear streaker's intake is vertically upward, and electron microscope pictures of filters indicate an upper size limit of 15 µm for particles collected. The Nuclepore filter is mounted on an aluminum frame which can be quickly inserted and removed from the streaker.

The streaker filters frames require no preparation before being placed in a specially designed vacuum chamber(3) where the filters are irradiated with 5 MeV protons from FSU's super-FN Tandem Van de Graaff. (A small vertical Van de Graaff dedicated to PIXE analysis is planned for operation in 1979 and will allow the production of 10^6 data points a year). The x-rays generated are detected using an energy dispersive Si(Li) detector purchased from Nuclear Semiconductor, which has a resolution of about 170 eV FWHM for the iron K x-ray (6.4 keV). The detector signals are processed using Nuclear Semiconductor electronics which include an amplifier, a pulse pile up rejector, a low level discriminator, and live time counter. Processed signals are fed into a Northern Scientific ADC which is Camac interfaced to an EMR 6130 on-line computer. At the end of each run the data is written on magnetic tape for off-line analysis. The PIXE technique is well understood(4) and the Elemental Analysis Group has taken part in numerous intercomparison studies.(5,6)

A sophisticated FORTRAN code REX(7) is used to fit the x-ray spectra. This code carefully models the spectra obtained. It contains information relevant to elemental x-ray line shapes, the Bremsstrahlung background, the silicon absorption edge, x-ray production cross sections, self absorption and attenuation, and other parameters. Absolute calibration is made from standards produced by Micro-Matter, Inc. and checked by PESA.(2)

During this experiment flow rates were maintained using a Mass Flow Controller TYLAN Model FC 260. The precision of this device was confirmed before and after the experiment using a spirometer and a factory calibrated variable area flowmeter (Matheson Model 601).

As a side experiment two other linear streakers were run. One was uncontrolled at 0.8 ℓ/m and one had a prefilter of 8 μm pore size. Modified Battelle cascade impactors were used as well with 4 hour sampling periods. These impactors have size cuts > 4, 4-2, 1-0.5, 0.5-0.25 and < 0.25 m, respectively. Mylar impaction surfaces and 0.4 μm Nuclepore afterfilters were employed. Petroleum jelly was used to coat the impaction surface except for the last impaction stage which was coated with parafin. Flow rates of the impactors were controlled by a critical flow orifice and were measured with a calibrated variable area flowmeter. Additional results from these samplers will be reported in a separate publication at a later date.

REFERENCES

1. Novel Aerosol Sampling Apparatus for Elemental Analysis, B. Jensen and J. W. Nelson, Proceedings of the 2nd International Conference on Nuclear Mehtods in Environmental Research - U. of Mo., July, 1974, US AEC Conf. - 740701, 385, Oak Ridge, Tenn.

2. Light Element Analysis by Proton Scattering, J. W. Nelson and W. J. Courtney, Nuclear Instruments and Methods 142, 127 (1977).

3. Proton Induced Aerosol Analysis: Methods and Samples, J. W. Nelson, X-ray Florescent Analysis Environmental Samples, Editor Thomas G. Dzubay, Ann Arbor Science Publishers, Inc. (1977).

4. Analytical Application of Particle Induced X-Ray Emission, Sven A. E. Johansson and Thomas B. Johansson, Nuclear Instruments and Method's 137, 473 (1976).

5. D. C. Camp, A. L. Van Lehn, J. R. Rhodes, A. H. Pradzynski, J. X-Ray Sepctr. 4, 123 (1975).

6. Continuous Observation of Particulates During the General Motors Sulfate Dispersion Experiment, W. J. Courtney, S. Rheingroves, J. Pilotte, H. C. Kaufmann, T. A. Cahill, and J. W. Nelson, Jour. APCA, March 1977.

7. Rex - A Computer Programme for PIXE Analysis, Henry C. Kaufmann, K. Roland Akselsson and William J. Courtney, Nuclear Instruments and Methods 142, 251 (1977).

AUTOMATED DICHOTOMOUS SAMPLERS

B. W. Loo
Lawrence Berkeley Laboratory.
Berkeley, CA 94720

QUALITY ASSURANCE MEASURES

Sampling

1. Flow calibrations performed in the field.
2. Automated flow controller in the sampler maintains the preset flow rate.
3. Fault sensors continuously check for filter loading, proper filter transport and vacuum seals.
4. Flow calibrations checked upon completion of study.

Analysis

1. Checked calibration and XRF spectrometer gain setting.
2. Checked helium level during XRF analysis.
3. Calibrate beta-gauge every hour.
4. Check and correct for long term beta-gauge response.
5. All samples measured twice for both total mass and elemental composition which checks for precision and any obvious error.

DETAILED ANALYTICAL METHODS AND PROCEDURES

Mass Measurement

A beta gauge consisting of a Pm^{147} source and a cooled Si detector was used. The areal mass of all filters was measured twice prior and subsequent to to field sampling. The measured beta intensity I was related to the sample thickness X in µg/cm^2 by $I = I_0 e^{-mx}$ where I_0 and µ were constants derived from a leastsquare fit to five calibration standards. These standards were gravimetrically weighted polycarbonate films of thicknesses 1034.6, 1511.9, 1970.6, 2552.2 and 2931.0 prg/cm^2. The counting times used for calibration and routine measurement were 100 and 30 sec. respectively. About 4×10^6 counts were accumulated within 30 sec. for a sample of 1 mg/cm^2. For a mean aerosol concentration of 107 µg/cm^2 the mean reproducibility was 4.7 µg/cm^2. A correction factor for long term systematic changes of 12.5 µg/cm^2 was determined from the remeasurement of 25 unexposed filters.

XRF Measurements

An XRF spectrometer including a pulsed x-ray source, cooled anti-coincidence guard-ring Si(Li) detector and fluorescent targets of Ti, Mo and Sm were used for elemental analysis. The x-ray calibration factors were determined using a series of thin-film standards which closely replicate the membrane filter samples. These standards are either uniform evaporation deposits of single element whose mass has been determined gravimetrically or multiple element standards in which the elemental concentration ratios are accurately known. For example the sulfur calibration was obtained by measuring specimens of 0.3 µm $CuSO_4 \cdot 5H_2O$ aerosols deposited on the surface of 0.1 µm pore size nucleopore filters. In this case evaporated deposits were used as primary standards. This calibration was cross-checked with that determined from a series of relative standards, namely K_2SO_4, $K_2Cr_2O_7$ and Cu-Cr mixed aerosol standards. The agreement was within 1%.

The x-ray attenuations due to the size of the particles were corrected using the method described by Dzubay and Nelson (Adv. in X-ray Anal. 18, 619, 1975). The values employed are listed as follows:

Element	Fine Particles	Coarse Particles
Si	0.93 ± 0.07	0.48 ± 0.15
S	0.97 ± 0.03	0.64 ± 0.22
Ca	0.99 ± 0.01	0.81 ± 0.13
Ti		0.87 ± 0.10
Fe		0.94 ± 0.05
Cu		0.94 ± 0.06
Zn		0.95 + 0.05

Due to the flow division within the virtual impactor, the reported values on size segregated samples have an implicit 5% interference of fine particle on the coarse particle fraction. This effect, of course, disperses when the two size fractions are summed. The only case where it may introduce any significant error is where the particles are found predominantly in fine particles and where the coarse particle size attenuation correction is large. This was the case with S and the attenuation corrections were applied after making the 5% fine particle interference correction.

CYCLONE SEQUENTIAL FILTER SAMPLERS

P. K. Mueller, D. A. Hansen and S. L. Heisler
Environmental Research & Technology, Inc.
2625 Townsgate Road
Westlake Village, California 91361

The samplers used in the aerosol sampler intercomparison conducted in Charleston, West Virginia between May 11 and May 19, 1977, were ERT Model 5200 Sequential Filter Samplers. The sampling head consists of a 5 cm I.D. by 50 cm long tube topped by a cylindrical shroud. The purpose of the shroud is to render the entry of large particles into the sampler relatively insensitive to changes in wind speed. The conical covering prevents entry of rain. Wire screens are located over the top and the bottom of the shroud to prevent entry of insects into the duct.

One of the samplers, F, was equipped with a cyclone preseparator located within the shroud. The Unico 240 cyclone used was calibrated for particle removal by Eisenbud and Kneip (1975). Based on their results, the 50 percent collection efficiency size for unit density spheres varied from 2.0 to 2.7 μm diameter as the flow rate varied over the range from 100 to 150 ℓpm. The sampler equipped with the cyclone collected only particles smaller than these sizes. The second sampler did not have a preseparator and collected particles smaller than approximately 15 μm diameter.

Sampled air passes through the inlet duct to the cylindrical chamber containing position for 13 filter holders. The circular arrangement of the filters subjects each to similar flow patterns. Air is never sampled through the thirteenth position; a filter is placed in this position to assess the effects of particle deposition when sampling is not occurring.

The filter holders are connected to a common pump through a system of solenoid valves. The valves are actuated by timers to allow sampling of the twelve filters in succession. The sampling times are programable for periods from 5 minutes to 24 hours by means of a 24-hour time switch. A sampling sequence can be programmed to start at any time within seven days after set-up. The deviation of the actual starting time from the programmed time is 30 minutes or less.

Flow rates are monitored continuously by means of a vacuum recorder connected upstream of the pump. The recorder is calibrated for flow rate.

The samplers accommodate open-face 47 mm diameter filter holders. The filter holders are equipped with quick-disconnect type fittings to allow easy installation and removal. Filters were shipped to and from the field in filter holders to eliminate the need for filter handling at the sites. A protective plastic cap is placed over the filter holder during shipment and handling.

The vacuum recorders in the samplers were calibrated three times during the program: on 10, 15, and 19 May 1977. Calibrations were performed with dry test meter attached at the sampler inlet. The cyclone preseparator was removed from the RSP sampler and the dry gas meter was connected in its place. Various types and combinations of filters were installed in the sampler to produce various flow rates for the calibration. The calibration was performed by cycling the sampler through these filters and recording the readings of the dry gas meter and the vacuum recorder. In the case of the TSP sampler which did not have a cyclone, the cylindrical chamber from the RSP sampler was installed for the calibration.

The results of the first and second and the second and third calibrations for each sampler were taken together and linear least-squares fits to each set of two calibrations were made. The calibration curve from the first set was used for reducing the data from the 11-14 May sampling; that from the second set was used for the 15-19 May sampling data.

CALCULATIONS OF CONCENTRATIONS

To calculate the volume of air sampled during each 3-hour sampling interval, the initial and final flow rates were averaged and multiplied by the time elasped during the interval.

The quantity of anionic material on each filter was determined as the product of the concentration of the anion in the extracted solution times any dilution factor times the reciprocal of the fraction of the filter which was extracted. These products, in nanograms, for four 3-hour intervals were added and the sum was divided by the sum of the volumes of air sampled during the four intervals to yield the average concentration of the anion in air, in ng m^{-3}, for each 12-hour reporting period.

FILTER MEDIUM

Particulate samples were collected on 47 mm diameter Teflon-impregnated glass fiber disks with the designation TX40HI20 manufactured by Pallflex Products Corp. to ERT specifications. This choice was based on the following considerations:

- The filter medium must retain particles efficiently while transmitting gases.
- Flow rates achievable using the filters in the Sequential Filter Samplers must be sufficient to allow collection of adequate material for analysis by the methods chosen.
- The filters must have sufficient mechanical strength for easy handling.

The first consideration, transmission of gases, eliminated ordinary glass fiber filters, because filters of this type have been shown to interact strongly with sulfur dioxide and other acid gases such as nitrogen oxides leading to erroneously high measurements of sulfates and nitrates. Membrane filters were eliminated by the second consideration because of their high flow resistance. The remaining types of filters to be considered were quartz fiber filters and the Teflon-impregnated glass fiber filters. Evaluation of the quartz fiber filters indicated they were too fragile to handle without significant loss of filter material.

GRAVIMETRIC ANALYSIS

Weighings were performed with a Cahn Model 4700 Automatic Electro-balance. Static charges were removed from the balances and from filters with Po^{210} ionization units located inside the weighing chambers in the balances.

Filters were equilibrated for a minimum of 24 hours in the balance room prior to weighing. The room was maintained between 23 and 25°C and at a relative humidity below 50 percent. Unexposed filters were equilibrated in the containers with the lid open in which they were received from the manufacturer. Exposed filters remained in the shipping containers with the lid open and the protective caps in place during equilibration.

Filters were inspected visually for defects prior to weighing. Unexposed filters showing defects were discarded.

The balance was operated at a full-scale range of 2000 μg with a resolution of 10 μg. Calibration was performed with Class M weights.

ANION ANALYSIS

Nitrate and sulfate were determined from a single extract by the technique developed by Small and co-workers (1975). This technique is called ion chromatography (IC).

A quarter of the filter was placed in a numbered borosilicate culture tube which had been previously cleaned and conditioned with eluent buffer, and 10 ml of buffer were added by means of a Repipet liquid dispenser. The tube was then capped and shaken ultrasonically or minutes in a Bransonic 32 ultrasonic cleaner. Because standing waves may exist at some points in the cleaner, the tubes were moved continuously during the extraction process.

Stock solutions of standard were prepared by dissolving analytical grade reagents in distilled deionized water and storing them in the refrigerator. Standard mixtures of NO_3^- and $SO_4^=$ were prepared in eluent buffer daily. All solutions were allowed to equilibrate at the instrument room condiitons before analysis.

A Model 10 ion chromatograph (Dionex Corp., Palo Alto, CA) was used for the analysis of the anions. For maximum resolution of the ions of interest, the instrument was operated at a pump speed of 2 ml/min. The eluent buffer was 0.001M Na_2CO_3 and 0.003M $NaHCO_3$ prepared in distilled deionized water having a conductivity of less than 0.1 μmho/cm. All samples were run at the 10 μmho full-scale setting.

A disposable syringe was used to load the solution into the sample loop.

Each sample was individually filtered in-line with a 0.2 μm pore size membrane filter during the sample-loading step in order to prevent contamination of the column with insoluble matter. Injections of the samples were spaced by fifteen minutes to allow complete elution of all anions.

For each ionic species, the peak height was measured from the defined baseline of initial to final inflection.

Calibration curves were prepared from a plot of peak height in inches versus concentration in μg/ml. The linear regression for each curve was used to reduce the data.

HIGH VOLUME AND DICHOTOMOUS SAMPLERS

Charles E. Rodes
Environmental Monitoring and Support Laboratory
Enivronmental Protection Agency
Research Triangle Park, NC 27711

INTRODUCTION

The Environmental Monitoring and Support Laboratory (EMSL) of EPA will participate in the Aerosol Sampler Comparison Study by operating 2 high-volume (hi-vol) samplers and 2 EMSL dichotomous samplers. EMSL will be responsible for all aspects of our portion of the study including: (1) equipment and personnel transportation, (2) set-up and take-down, (3) oepration during the 8 day period and (4) analysis for selected parameters.

SAMPLING DEVICES AND FILTER SUBSTRATES

The hi-vols used will conform to the standard Federal Register (1) requirements with the addition of constant mass flow controllers and Dixon flow recorders. The hi-vols will be operated at 1.42 sm^3/min (50 SCFM) using acid washed 200 x 250 cm (8 x 10 in.) glass fiber filters.

The EMSL dichotomous samplers have the standard "Coarse" and "Fine" channels with a 3.5 um cutpoint and an inlet cut-off of $\sim$ 20 µm. These samplers also include a separate "Total" channel which collects aerosols $\overset{\sim}{<}$ 20 µm. Flow control is maintained by critical flow valves with rotameters on all 3 channels. The sampler utilizes 37 mm Fluoropore Teflon filters with a polyethylene backing. These filters are backed with a 37 mm cellulose pad and placed in circular holders which fit holders in the respective sampler channels.

QUALITY CONTROL

The samplers will be checked for flow calibration only. All samplers will be calibrated initially in RTP using a Rootsmeter® as the traceable standard. After the samplers are set up in the field, transfer flow standards will be used to audit check the flowrate initially and in the middle of the study. A standard audit orifice also calibrated using the Rootsmeter® is used to check the hi-vols. A 300 mm rotameter calibrated in the lab against a dray-test meter is used to audit check the "Total" and "Fine" dichotomous channels. The "Coarse" channel is checked with a calibrated mass flowmeter. At the conclusion of the study all samplers will be recalibrated with the audit flow devices.

During sample collection a change in flowrate from the beginning to the end of a sampling period (12 hrs) of ± 15% is allowable. Flow changes greater than this would invalidate the respective sample.

In order to obtain reproducibility information 2 samplers of each type will be operated simultaneously for 8 sample periods (4 days). After these comparison tests the samplers will be operated alternately to obtain only one sample of each type per time period.

ANALYSES

The primary measurements will be gravimetric mass using a 5-place balance, with subsequent analyses for sulfate ($SO_4^=$) by the MTB method and lead (Pb) by atomic absorption. Mass measurements will be made on all fiters. Two measurements - $SO_4^=$ and Pb - will be performed on all samples collected except the duplicate dichotomous samples. The wet chemistry and mass analyses will be performed by the Analytical Chemistry Branch of EMSL.

REFERENCES

1. Federal Register, Vol. 36, No. 84, April 30, 1971, pp. 8191-8194.

HIGH VOLUME AND DIFFUSION SAMPLER

Roger L. Tanner and Leonard Newman
Atmospheric Sciences Division
Brookhaven National Laboratory
Upton, New York 11973

The samplers used in this study are a conventional Staplex High Volume sampler sampling at about 0.9 m^3/min and a diffusion sampler sampling through three 47 mm filters at a total flow rate of about 2.5 m^3/hr. The Hi-Vol sampler samples all particles less than about 20 μm in diameter. All three diffusion-processed samples were taken through an entrance tube that excluded most particles larger than about 5 μm in diameter: Sample DB0 samples all remaining size ranges of particles; particles smaller than about 0.04 μm are removed by diffusion from sample DB1, particles smaller than about 0.1 μm are removed from sample DB2.

Samples from both the Staplex HiVol and the diffusion sampler were collected on phosphoric acid-treated quartz filters (1) (Pall Corp., Putnam, Conn., Type GAO). This filter material is prepared as follows: the filter as received is ignited overnight at 750°C to remove binder material; filter is then washed then treated with hot (80°C) phosphoric acid; following a rinse to remove excess H_3PO_4, filter is reignited to 750°C. A post-ignition rinse in Ph 5 HCl removes excess P_2O_5 and following drying at 100°C, the filter is ready for use. The HiVol sampler was also used to collect an SO_2 sample during each period on two K_2CO_3, glycero-impregnated cellulose filters in series with the quartz prefilter.

The HiVol sampler was mounted in a conventional HiVol enclosure protected from precipitation and could be operated under any precipitation conditions. The diffusion-sampling pump was placed in a protective box but in the absence of an enclosed shed, no protection was used with the diffusion battery and filter holders; although no diffusion sampling during heavy rain conditions could be conducted, these conditions were not encountered during the study.

The HiVol sampler has been calibrated with the filter pack in place using a magnetohelic guage. Decreses in flow during 12 hr sampling were checked out after the experiment and found to be less than 1 cfm, insignificantly low to require measurement for each sample. The diffusion sampler has been calibrated using unrestricted Matheson rotameter tubes in series upstream from the three 47 mm filter holders, (i.e., in line at ambient pressure). This calibration was assumed to hold constant for 47 mm quartz filters from the same batch of treated quartz. The calibration was checked after the experiment for constancy; changes of only a few % were observed and the average of flows before and after the Intercomparison were used for sample volume calculations.

Each 4-in diameter, HiVol quartz particulate filter was quartered with one filter quarter sequentially extracted by benzaldehyde and isopropanol and the extract contents analyzed for H_2SO_4 and bisulfate, respectively, by the flash volatilization-FPD techique (3). A second quarter was extracted into pH 4 aqueous solution and soluble strong acid determined by Gran titration (1), ammonium and nitrate ions by Autoanalyzer colorimetric techniques (1), and soluble sulfate determined by ion chromatography (4) and also by Methylthymol Blue colorimetry (5). The reamining quarters were saved for replicate determinations as needed or for cross checks of sulfur content by the reduction-sliver-110 technique (2). The SO_2 was determined in the two K_2CO_3, glycerol-impregnated cellulose backup filters by extraction into aqueous peroxide with determination as sulfate by ion chromatographic or turbidimetric Autoanalyzer techniques.

The diffusion-processed samples, collected on 47 mm treated quartz filters, were bisected. One half was analyzed for soluble strong H^+, NH_4^+, SO_4^{2-} and NO_3^- by the methods described above; the second half was sequentially extracted by benzaldehyde for determination of H_2SO_4 and also by the techniques described above.

REFERENCES

(1) R. L. Tanner, R. Cederwall, R. Garber, D. Leahy, W. Marlow, R. Meyers, M. Phillips and L. Newman, "Separation and Analysis of Aerosol Sulfate Species at Ambient Concentrations", Atoms. Environ., 11, 955 (1977).

(2) J. Forrest and L. Newman, "Application of ^{110}Ag Microgram Sulfate Analysis for the Short Time Resolution of Ambient Levels of Sulfur Aerosol", Anal. Chem., 49, 1579 (1977).

(3) R. L. Tanner, R. W. Garber and L. Newman, "Speciation of Sulfate in Ambient Aerosols by Solvent Extraction with Flame Photometric Detection", 173rd National Meeting, American Chemical Society, New Orleans, LA, March 20-25, 1977.

(4) W. E. Rich, "Analysis of Nitrate and Sulfate Collected on Air Filters", Application Note No. 2, Dionex Corp., Palo Alto, CA, January 23, 1976.

(5) J. M. Adamski and S. P. Villard, "Application of the Methylthymol Blue Sulfate Method to Water and Wastewater Analysis", Anal. Chem., 47, 1191 (1975).

APPENDIX B

OUTLIER AND REGRESSION ANALYSIS EQUATIONS

OUTLIER TEST

The Dixon criterion is a statistical test applied to any set of n observation, where $n \geq 3$. Its objective is to identify an observation, which to within a chosen probability, does not belong to the other (n -1) observations. These do not include observations where there is a known cause for its deviation. Otherwise when the deviation is larger than one can reasonably expect, this should serve as a stimulus to discover what happened. If it appears that nothing happened then the results in this intercomparison study were left as is; however, the outlying values were flagged for all to see.

Let n be defined as the number of real non-zero sampler concentrations reported for a given period of the intercomparison study. Four coefficients are defined by each periods result set; however, only one coefficient will apply. Its use and definition depend on the number of results for that period, and whether the suspected observation lies at the low or high end. If the observations are ordered from 1 to n, where the first value, X_1, is the lowest concentration reported and X_n is the greatest, then the four coefficients are defined as follows depending on n.

$$r_1: \quad 3 \leq n \leq 7 \qquad \text{(B-1)}$$
$$r_2: \quad 8 \leq n \leq 10 \qquad \text{(B-2)}$$
$$r_3: \quad 11 \leq n \leq 13 \qquad \text{(B-3)}$$
$$r_4: \quad 14 \leq n \leq 25 \qquad \text{(B-4)}$$

If result X_n is suspect, then

$$r_1 = (X_n - X_{n-1})/(X_n - X_1) \qquad \text{(B-5)}$$
$$r_2 = (X_n - X_{n-1})/(X_n - X_2) \qquad \text{(B-6)}$$
$$r_3 = (X_n - X_{n-2})/(X_n - X_2) \qquad \text{(B-7)}$$
$$r_4 = (X_n - X_{n-2})/(X_n - X_3) \quad . \qquad \text{(B-8)}$$

If the result X_1 is suspect, then

$$r_1 = (X_2 - X_1)/(X_n - X_1) \qquad \text{(B-9)}$$
$$r_2 = (X_2 - X_1)/(X_{n-1} - X_1) \qquad \text{(B-10)}$$
$$r_3 = (X_3 - X_1)/(X_{n-1} - X_1) \qquad \text{(B-11)}$$
$$r_4 = (X_3 - X_1)/(X_{n-2} - X_1) \quad . \qquad \text{(B-12)}$$

The r_j coefficients are calculated and compared to tabulated coefficients $r(1-\alpha/2)$, where α is defined as the probability assumed in rejecting a result that really belongs in the group. For the intercomparison study α was defined as 4%, thus any value greater than 2% high or less than 2% low would be defined as an outlier.

The calculated r_i coefficients are compared to standard tables, a portion of which is given in Table B-1. Although α was chosen as 4%, if α is chosen smaller the coefficients will become larger and the likelihood of rejection decreases.

TABLE B-1. CRITERIA FOR REJECTION OF OUTLYING OBSERVATIONS

		Upper Percentiles					Upper Percentiles		
Coefficient	# of Observ.	α=10 .95	α=4 .98	α=2 .99	Coefficient	# of Observ.	α=10 0.95	α=4 0.98	α=2 0.99
r_1	3	.941	.976	.988	r_3	11	.576	.638	.679
	4	.765	.846	.889		12	.546	.605	.642
	5	.642	.729	.780		13	.521	.578	.615
	6	.560	.644	.698	r_4	14	.546	.602	.641
	7	.507	.586	.637		15	.525	.579	.616
r_2	8	.554	.631	.683		16	.507	.559	.595
	9	.512	.587	.635		17	.490	.542	.517
	10	.477	.551	.597		⋮	⋮	⋮	⋮

More detailed information on the Dixon criterion can be found in Experimental Statistics, a National Bureau of Standards Handbook 91, Chapter 17, by M. G. Natrella, issued August 1, 1963, reprinted October 1966, with corrections.

REGRESSION ANALYSIS

Assume that the pollutant concentration results obtained for sampler Y are linearly correlated with those obtained for sampler X. Let j be the period number (j = 1, 2, 3,..., 16). Then for any sampler Y we can write

$$y = a + bx \qquad \text{(B-13)}$$

The intercept, a, will be given by

$$a = \frac{1}{n}\left[\Sigma Y - \frac{SXY}{SXX}\,\Sigma X\right] \qquad \text{(B-14)}$$

and

$$b = \frac{SXY}{SXX} = \frac{\Sigma XY - \frac{1}{n}\Sigma X\,\Sigma Y}{\Sigma X^2 - \frac{1}{n}\,(\Sigma X)^2} \qquad \text{(B-15)}$$

and n is defined as the number of paired X_jY_j values (≤ 16). Note that when regression analysis is performed between any sampler and the composite Z-means there will always be 16 Z_j values, but not necessarily 16 paired Y_jZ_j values.

Similarly, when regression analysis is performed between any two samplers X_jY_j, the number of paired values will define n. The errors ϵ_a and ϵ_b can also be calculated using

$$\epsilon_a = \left| \frac{1}{n-2} \left[\Sigma Y^2 - \frac{1}{n}(\Sigma Y)^2 - \frac{(SXY)^2}{SXX}\right] \left[\frac{1}{n} + \frac{(\bar{X})^2}{SXX}\right] \right|^{\frac{1}{2}} \qquad \text{(B-16)}$$

where $\bar{X} = \frac{1}{n}\Sigma X_j$ and $\bar{Y} = \frac{1}{n}\Sigma Y_j$

$$\epsilon_b = \left| \frac{1}{n-2} \frac{1}{SXX} \left[\Sigma Y^2 - \frac{1}{n}(\Sigma y)^2 = \frac{SXY}{SXX}\right] \right|^{\frac{1}{2}} \qquad \text{(B-17)}$$

The root mean square residual, r, of the fit is one measure of how well the two samplers define a linear relationship. The results from two samplers may tightly define their mutual slope, b, in which case r is small. However, if two samplers report widely fluctuating values, then r will be large. If all samplers are compared to the composite sampler, then an intercomparison of their respective r's is a measure of their relative precisions (assuming that b is approximately 1.0). The root mean square residual concentration for sampler Y relative to sampler X is defined by

$$r = \left[\frac{1}{m} \sum_{j=1}^{m} (Y_j - \hat{Y})^2\right]^{\frac{1}{2}} \text{ in ng/m}^3 \text{ (or } \mu\text{g/m}^3\text{)} \quad , \qquad \text{(B-18)}$$

where there are m concentration results for sampler Y_j and $\hat{Y}$ is given by (B-13). Finally, it is useful to examine how well the two samplers X and Y are correlated, i.e., how linearly related there concentrations are. The correlation coefficient is given by

$$(bXY \cdot bYX)^{\frac{1}{2}} = \left(\frac{SXY}{SXX} \frac{SYX}{SYY}\right)^{\frac{1}{2}} \qquad \text{(B-19)}$$

SXY was given in (B-15) and SYX is obtained by interchanging X and Y in that expression.

The intercept and its error, the slope and its error, the root mean square deviation in µg or ng/m^3, and the correlation coefficient are listed in Appendix C for each sampler that reported results for any pollutant fraction or total concentration.

More detailed information on linear regression analysis of two variables can be found in Experimental Statistics, a National Bureau of Standards Handbook 91, Chapter 5, by M. G. Natrella, issued August 1, 1963, reprinted October 1966, with corrections.

APPENDIX C

Table of Contents

Introduction, Definitions, and Comments 100

Pollutant Total/Small/Large

Mass 101

Nitrate 104

Sulfate 107

Sulfur 110

Sulfur + Sulfate 113

Silicon 116

Calcium 119

Titanium 122

Iron 125

Copper 128

Zinc 131

Selenium 133

Bromine 136

Lead 139

INTRODUCTION DEFINITIONS COMMENTS

POLLUTANT RESULTS ARE GROUPED TOTAL, SMALL, & LARGE WITH THE FOLLOWING ORDER: MASS, NO3, SO4, S, S+SO4, & TRACE ELEMENTS-SI, CA, TI, FE, CU, ZN, SE, BR, & PB.

TOTAL:REPORTED TOTAL CONCENTRATIONS OR SUM OF ALL FINE & COARSE FRACTION RESULTS

SMALL: USUALLY THE FINE FRACTION(S); CUT POINTS WILL VARY WITH SAMPLER TYPE: SMALL MEANS ABOUT 3.0 + OR - 0.5 MICROMETERS AND SMALLER

LARGE: THE COARSE FRACTION; INLET RESTRICTIONS AND FINE CUT POINTS VARY ALSO. LARGE MEANS ABOUT 3.0 + OR -0.5 MICROMETERS AND GREATER, UP TO THE INLET CUTOFF

MASS RESULTS & ERRORS(NOT SHOWN) ARE PUNCHED IN TENTHS OF MICROGRAMS/CUBIC METER BUT ROUNDED OFF IN THE TABLES. ALL OTHER RESULTS ARE LISTED IN NANOGRAMS/CUBIC M

SAMPLER DEFINITIONS

DICOT= AUTOMATED DICHOTOMOUS SAMPLERS (3-C, L, & S) FROM LBL-LOO
DICOT= AN ERC DICHOTOMOUS SAMPLER (1 - O) FROM EPA-RODES
HIVOL= HIGH VOLUME SAMPLERS (3: A FROM BNL-TANNER & P/T FROM EPA-RODES/BURTON)
LS = LINEAR STREAKER SAMPLERS (2 - J & K) FROM FLA.ST.UNIV.- HUDSON
MDS = MANUAL DICHOTOMOUS SAMPLERS (2 - D & R) FROM EPA-DZUBAY
RSP = CHAMP SAMPLERS(2-B&U) FROM EPA-BURTON; CYCLONE SAMPLER(1-F) FROM MUELLER
SMDAY= SIERRA MULTIDAY SAMPLER (1 - G) 3-STAGES UNIV.CA.DAVIS-CAHILL
SFU = STACKED FILTER UNIT (1 - I) 2-STAGES FROM UNIV.CA.DAVIS-CAHILL
TTLF = TOTAL FILTER UNIT (1 - H) 1-STAGE FROM UNIV.CA.DAVIS-CAHILL
TSP = CYCLONE SAMPLER (1 - E) FROM ERT-MUELLER
2MASS= TWO MASS SAMPLER (1 - Q) FROM WASH.UNIV.,ST.LOUIS-DELUMYEA/MACIAS

FOR EACH POLLUTANT, THE FIRST RESULT TABLE LISTS THE REPORTED CONCENTRATIONS AS A FUNCTION OF PERIOD, EACH 12 HOURS LONG, AND LISTED FROM COLUMNS 1 THROUGH 16.

EACH SAMPLER IS ASSIGNED AN ALPHABETICAL INDEX ACCORDING TO ITS SPATIAL LOCATION AT THE FIELD STUDY. SEE FIGURE 1 AND TABLE 4 IN THE TEXT FOR MORE INFORMATION.

A DASH - ENTERED IN THE TABLE INDICATES NO VALUE REPORTED FOR THAT SAMPLER & PD. OUTLIER VALUES ARE DENOTED BY A -(NEG) SIGN BUT ARE INCLUDED IN MEAN CALCULATION

THE Z-MEAN INCLUDES ALL SAMPLER RESULTS & OUTLIERS EXCEPT THOSE IN PARENTHESIS.

THE X-MEAN INCLUDES ONLY THOSE SAMPLER RESULTS NOTED IN PARENTHESIS-NO DUPLICATE

THE SECOND TABLE LISTS RATIOS OF REPORTED RESULTS TO THE APPROPRIATE Z-MEANS. THE LAST 3 COLUMNS LIST THE 16-PERIOD AVERAGE RATIOS, THEIR STANDARD DEVIATIONS, AND THE PERCENT ERROR ASSOCIATED WITH THAT STD.DEV.(COEFFICIENT OF VARIATION).

AN ASTERISK BY ENTRIES IN THIS TABLE INDICATE THAT A PARTICIPANTS REPORTED ERROR FOR THAT PERIOD ALLOWS HIS RESULT TO OVERLAP 1.0 OR THE Z-MEAN CONCENTRATION.

NOTE THAT THE STANDARD DEVIATIONS VS PD. IN THE MEAN RATIOS INDICATE THE DEGREE OF SCATTER IN THE REPORTED CONCENTRATIONS FOR THAT PARTICULAR PERIOD & POLLUTANT

THE LAST TABLE LISTS THE RESULTS OF A LINEAR REGRESSION ANALYSIS OF EACH SAMPLER WITH THE Z-MEAN. LEFT TO RIGHT ARE THE INTERCEPT,ITS ERROR; THE SLOPE,ITS ERROR; THE ROOT MEAN SQUARE DEVIATION IN CONC. UNITS; AND THE CORRELATION COEFFICIENT.

1

INTERCOMPARISON STUDY OF TOTAL MASS; MICROGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD
D	EPA	DZUBAY	MDS-A	70	69	68	71	93	-	84	90	-	48	69	75	90	-	114	103	D		
R	EPA	DZUBAY	MDS-S	66	70	71	71	85	86	94	93	42	-	80	82	96	119	125	108	R		
C	LBL	LOO	DICOT	-	-	-	96	108	117	110	-	47	63	98	97	116	126	133	120	C		
L	LBL	LOO	DICOT	86	95	95	97	113	122	115	-	50	74	106	98	128	132	142	132	L		
S	LBL	LOO	DICOT	99	96	109	-	124	118	127	-	48	77	-	-	-	137	139	126	S		
P	EPA	RODES	HIVOL	114	138	123	116	159	129	134	113	51	89	126	112	158	137	183	127	P		
B	EPA	BURTON	CHAMP	92	98	97	89	122	120	117	114	57	82	110	113	131	149	159	147	B		
T	EPA	BURTON	HIVOL	119	114	117	115	161	124	132	120	50	95	124	122	150	156	177	138	T		
U	EPA	BURTON	CHAMP	74	89	94	99	126	121	112	112	46	81	104	118	137	149	165	139	U		
E	ERT	MULLER	TSP	63	74	79	82	85	99	91	97	34	52	86	80	94	113	125	114	E		
Q	STL	DEL/ED	2MASS	39	153	97	136	-	-	-	-	-	92	-	-	111	157	-	-	Q		
Z MEAN(WITHOUT Q)				87	94	95	93	118	115	111	106	47	73	100	100	122	136	146	125		104	18
STANDARD DEVIATION				20	22	19	17	27	14	17	12	6	16	19	18	25	14	23	14			
X MEAN(D,L,P,T,U,E)				88	96	96	97	123	119	111	106	46	73	103	101	126	138	151	125			
STANDARD DEVIATION				23	26	21	18	32	12	21	13	7	19	22	20	28	15	28	14			

RATIO TO Z			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD	CV
D	EPA	DZUBAY	MDS-A	0.81	0.73	0.72	0.77	0.79	-	0.75	0.85	-	0.66	0.69	0.75	0.74	-	0.78	0.82	D	0.76	0.05	7
R	EPA	DZUBAY	MDS-S	0.76	0.75	0.75	0.76	0.72	0.75	0.84	0.88	0.89	-	0.80	0.82	0.79	0.87	0.86	0.86	R	0.81	0.06	7
C	LBL	LOO	DICOT	-	-	-	•1.03	0.92	•1.02	•0.98	-	•0.99	0.86	•0.97	•0.98	0.95	0.93	0.91	0.96	C	0.96	0.05	5
L	LBL	LOO	DICOT	•0.99	•1.02	•1.00	1.04	0.96	1.06	•1.03	-	•1.05	•1.01	1.05	•0.98	1.05	•0.97	•0.97	1.05	L	1.02	0.04	3
S	LBL	LOO	DICOT	1.14	•1.03	1.15	-	1.05	•1.02	1.14	-	•1.03	•1.05	-	-	-	•1.01	0.95	•1.01	S	1.05	0.06	6
P	EPA	RODES	HIVOL	1.31	1.47	1.30	1.25	1.35	1.12	1.20	1.07	1.09	1.22	1.27	1.13	1.29	•1.01	1.25	•1.02	P	1.21	0.13	11
B	EPA	BURTON	CHAMP	1.06	1.05	1.02	0.95	1.04	1.05	1.05	1.08	1.20	1.11	1.09	1.13	1.08	1.10	1.08	1.17	B	1.08	0.06	5
T	EPA	BURTON	HIVOL	1.37	1.22	1.24	1.24	1.37	1.08	1.18	1.14	1.07	1.29	1.23	1.23	1.22	1.15	1.21	1.10	T	1.21	0.09	7
U	EPA	BURTON	CHAMP	0.86	0.95	•1.00	1.06	1.07	1.05	•1.00	1.07	0.96	1.11	1.03	1.18	1.12	1.10	1.13	1.11	U	1.05	0.08	8
E	ERT	MULLER	TSP	0.72	0.80	0.84	0.89	0.72	0.86	0.81	•0.91	0.72	0.70	0.85	0.81	0.77	0.87	0.85	0.91	E	0.81	0.07	8
Q	STL	DEL/ED	2MASS	0.45	1.64	•1.03	1.47	-	-	-	-	-	1.25	-	-	0.91	1.15	-	-	Q	1.13	0.39	34
MEAN(WITHOUT Q)				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		
STANDARD DEVIATION				0.24	0.24	0.21	0.18	0.23	0.12	0.16	0.12	0.14	0.22	0.19	0.18	0.20	0.10	0.16	0.11		0.17		

REGRESSION VS Z				INTERCEPT	ERROR	SLOPE	ERROR	RMS.DEV.	COR.COEFF.
D	EPA	DZUBAY	MDS-A	-12.792	7.763	0.883	0.073	4.793	0.965
R	EPA	DZUBAY	MDS-S	-7.218	7.574	0.875	0.070	6.127	0.961
C	LBL	LOO	DICOT	4.581	5.906	0.914	0.054	4.826	0.983
L	LBL	LOO	DICOT	4.120	4.584	0.974	0.043	4.009	0.988
S	LBL	LOO	DICOT	11.766	8.002	0.933	0.074	6.743	0.973
P	EPA	RODES	HIVOL	12.214	16.288	1.089	0.152	14.258	0.886
B	EPA	BURTON	CHAMP	-0.725	6.356	1.083	0.060	5.564	0.980
T	EPA	BURTON	HIVOL	6.565	10.501	1.144	0.098	9.192	0.952
U	EPA	BURTON	CHAMP	-16.800	8.048	1.219 .	0.075	7.045	0.974
E	ERT	MULLER	TSP	-11.956	7.314	0.937	0.068	6.403	0.965
Q	STL	DEL/ED	2MASS	0.	0.	0.	0.	0.	0.

1

INTERCOMPARISON STUDY OF SMALL MASS: MICROGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD
D	EPA	DZUBAY	MDS-A	37	43	35	41	41	-	45	56	-	22	37	45	57	-	64	75	D		
R	EPA	DZUBAY	MDS-S	36	42	34	41	42	54	46	64	25	-	41	48	58	79	64	73	R		
C	LBL	LOO	DICOT	34	-	-	41	42	60	51	-	32	27	42	52	60	77	66	73	C		
L	LBL	LOO	DICOT	34	41	38	40	44	61	51	-	30	24	43	50	52	80	68	76	L		
S	LBL	LOO	DICOT	36	40	34	-	44	57	52	-	30	24	42	-	63	77	64	72	S		
O	EPA	RODES	DICOT	21	52	20	46	27	58	46	73	38	35	46	28	49	73	70	67	O		
B	EPA	BURTON	CHAMP	64	59	65	58	74	77	73	83	46	48	79	75	108	107	117	99	B		
U	EPA	BURTON	CHAMP	52	52	66	59	79	76	71	82	42	44	78	73	103	104	112	97	U		
F	ERT	MULLER	RSP	38	42	42	49	48	59	51	69	22	23	59	53	67	79	72	76	F		
Q	STL	DEL/ED	2MASS	17	55	37	46	-	51	-	57	-	33	-	-	53	72	58	69	Q		
Z MEAN(ALL SAMPLERS)				37	47	41	47	49	61	54	69	33	31	52	53	68	83	76	78		55	13
STANDARD DEVIATION				14	7	15	7	17	9	11	11	8	10	16	15	20	13	21	11			
X MEAN(D,L,O,U,F,Q)				33	48	40	47	48	61	53	67	33	30	53	50	65	82	74	77			
STANDARD DEVIATION				13	6	15	7	19	9	11	11	9	9	16	16	20	13	19	11			

RATIO TO Z			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD	CV
D	EPA	DZUBAY	MDS-A	•1.01	•0.92	0.85	0.89	0.83	-	0.83	0.82	-	0.70	0.72	0.85	0.84	-	0.85	•0.97	D	0.85	0.09	10
R	EPA	DZUBAY	MDS-S	•0.98	0.90	0.82	0.87	0.86	0.87	0.85	0.92	0.75	-	0.79	0.91	0.86	0.95	0.85	0.94	R	0.88	0.06	7
C	LBL	LOO	DICOT	•0.93	-	-	0.89	0.85	•0.97	•0.95	-	•0.96	0.86	0.81	•0.99	0.88	0.93	0.88	0.94	C	0.91	0.05	6
L	LBL	LOO	DICOT	•0.93	0.87	•0.92	0.85	0.90	•0.99	•0.95	-	•0.90	0.77	0.82	•0.94	0.91	•0.96	0.90	•0.97	L	0.91	0.06	7
S	LBL	LOO	DICOT	•0.98	0.84	0.82	-	0.90	0.93	•0.96	-	•0.90	0.78	0.81	-	0.93	0.92	0.84	0.92	S	0.89	0.06	7
O	EPA	RODES	DICOT	0.56	•1.10	0.48	•0.97	0.54	•0.94	0.85	•1.05	•1.15	•1.14	•0.89	0.52	0.71	0.88	•0.93	0.87	O	0.85	0.22	26
B	EPA	BURTON	CHAMP	1.75	1.24	1.57	1.24	1.52	1.26	1.35	1.21	1.40	1.55	1.52	1.41	1.59	1.28	1.55	1.27	B	1.42	0.16	11
U	EPA	BURTON	CHAMP	1.41	1.10	1.60	1.27	1.61	1.24	1.31	1.19	1.26	1.42	1.50	1.38	1.51	1.25	1.49	1.25	U	1.36	0.15	11
F	ERT	MULLER	RSP	•1.02	0.88	•1.02	•1.04	•0.99	•0.96	•0.95	•0.99	0.68	0.72	1.13	•1.00	•0.98	•0.96	•0.96	•0.98	F	0.95	0.11	12
Q	STL	DEL/ED	2MASS	0.45	1.16	0.91	•0.99	-	0.84	-	0.82	-	1.07	-	-	0.79	0.87	0.76	0.89	Q	0.87	0.18	21
MEAN(ALL SAMPLERS)				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		
STANDARD DEVIATION				0.37	0.15	0.37	0.16	0.34	0.15	0.19	0.16	0.25	0.32	0.31	0.29	0.30	0.15	0.28	0.14		0.25		

REGRESSION VS Z				INTERCEPT	ERROR	SLOPE	ERROR	RMS.DEV.	COR.COEFF.
D	EPA	DZUBAY	MDS-A	-3.069	4.658	0.910	0.084	4.228	0.957
R	EPA	DZUBAY	MDS-S	-5.460	2.818	0.978	0.048	2.767	0.985
C	LBL	LOO	DICOT	-0.986	2.939	0.929	0.051	2.951	0.984
L	LBL	LOO	DICOT	-5.364	2.398	1.013	0.043	2.589	0.989
S	LBL	LOO	DICOT	-2.708	2.852	0.942	0.050	3.006	0.985
O	EPA	RODES	DICOT	-4.244	9.670	0.928	0.169	10.569	0.826
B	EPA	BURTON	CHAMP	10.248	7.855	1.215	0.138	8.585	0.921
U	EPA	BURTON	CHAMP	6.089	7.678	1.244	0.135	8.392	0.927
F	ERT	MULLER	RSP	-4.533	3.859	1.047	0.068	4.218	0.972
Q	STL	DEL/ED	2MASS	4.418	8.557	0.784	0.142	8.073	0.879

1

INTERCOMPARISON STUDY OF LARGE MASS: MICROGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD
D	EPA	DZUBAY	MDS-A	33	25	33	30	52	-	39	33	8	27	32	30	33	-	50	28	D		
R	EPA	DZUBAY	MDS-S	30	28	37	30	43	32	48	30	17	38	39	34	38	40	61	35	R		
C	LBL	LOO	DICOT	-	-	-	54	66	58	58	-	15	37	56	45	56	49	67	47	C		
L	LBL	LOO	DICOT	52	54	57	57	69	61	64	-	20	50	63	48	66	52	75	56	L		
S	LBL	LOO	DICOT	63	57	75	-	80	61	75	-	19	52	-	-	-	61	76	54	S		
O	EPA	RODES	DICOT	24	42	41	36	57	19	42	-46	29	-95	51	28	29	135	57	29	O		
B	EPA	BURTON	CHAMP	27	39	32	31	48	43	44	30	11	34	30	38	24	42	42	48	B		
U	EPA	BURTON	CHAMP	23	36	29	39	48	45	41	30	4	37	25	45	34	45	53	42	U		
Q	STL	DEL/ED	2MASS	23	98	60	90	-	-	-	-	-	59	-	-	57	84	-	-	Q		
Z MEAN(WITHOUT Q)				36	40	43	40	58	46	51	34	15	46	42	38	40	60	60	42		43	14
STANDARD DEVIATION				15	12	17	12	13	16	13	7	8	22	14	8	15	33	12	11			
X MEAN(D,L,O,U)				33	39	40	41	56	42	46	37	15	52	43	38	40	77	59	39			
STANDARD DEV!ATION				14	12	13	12	9	21	12	9	11	30	17	10	17	50	11	13			

RATIO TO Z			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD	CV
D	EPA	DZUBAY	MDS-A	•0.92	0.63	0.76	0.76	0.89	-	0.76	•0.98	0.54	0.57	0.76	0.79	0.83	-	0.84	0.66	D	0.76	0.13	17
R	EPA	DZUBAY	MDS-S	0.84	0.69	0.85	0.75	0.75	0.70	0.93	0.87	•1.13	0.82	0.91	0.89	•0.95	0.65	•1.01	0.82	R	0.85	0.13	15
C	LBL	LOO	DICOT	-	-	-	1.37	1.15	1.26	1.14	-	•1.00	0.79	1.32	1.17	1.41	0.81	1.12	1.12	C	1.14	0.20	17
L	LBL	LOO	DICOT	1.44	1.34	1.32	1.44	1.19	1.34	1.25	-	1.29	1.09	1.50	1.25	1.65	0.86	1.24	1.33	L	1.30	0.18	14
S	LBL	LOO	DICOT	1.76	1.41	1.73	-	1.38	1.33	1.47	-	•1.22	1.14	-	-	-	•1.00	1.26	1.28	S	1.36	0.23	17
O	EPA	RODES	DICOT	•0.66	•1.05	•0.94	•0.91	•0.99	0.42	•0.81	•1.37	•1.87	2.06	•1.21	•0.72	•0.72	2.22	•0.96	•0.68	O	1.10	0.53	49
B	EPA	BURTON	CHAMP	0.76	0.98	0.74	0.77	0.83	0.95	0.85	0.89	0.70	0.73	0.71	•1.00	0.60	0.70	0.69	1.13	B	0.81	0.14	17
U	EPA	BURTON	CHAMP	0.63	0.90	0.66	•0.99	0.82	0.99	0.79	0.89	0.26	0.80	0.59	1.18	0.85	0.75	0.88	0.98	U	0.81	0.21	26
Q	STL	DEL/ED	2MASS	0.63	2.45	1.38	2.28	-	-	-	-	-	1.27	-	-	1.44	1.40	-	-	Q	1.55	0.62	40
MEAN(WITHOUT Q)				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		
STANDARD DEVIATION				0.43	0.30	0.39	0.29	0.22	0.35	0.26	0.21	0.50	0.47	0.34	0.21	0.38	0.55	0.20	0.26		0.33		

REGRESSION VS Z				INTERCEPT	ERROR	SLOPE	ERROR	RMS.DEV.	COR.COEFF.
D	EPA	DZUBAY	MDS-A	-3.987	5.397	0.869	0.125	4.874	0.895
R	EPA	DZUBAY	MDS-S	4.583	5.584	0.728	0.125	5.384	0.841
C	LBL	LOO	DICOT	10.610	10.497	0.892	0.226	9.220	0.780
L	LBL	LOO	DICOT	17.942	8.793	0.873	0.195	8.145	0.780
S	LBL	LOO	DICOT	12.541	12.021	1.072	0.256	10.440	0.813
O	EPA	RODES	DICOT	-17.514	26.225	1.501	0.588	25.282	0.563
B	EPA	BURTON	CHAMP	4.496	6.347	0.709	0.142	6.119	0.799
U	EPA	BURTON	CHAMP	-3.302	7.006	0.906	0.157	6.754	0.839
Q	STL	DEL/ED	2MASS	0.	0.	0.	0.	0.	0.

```
1                    INTERCOMPARISON STUDY OF TOTAL NO3 :  NANOGRAMS/CUBIC METER: PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD

R  EPA  DZUBAY  MDS-S    1270   850  1360   710  1810  1250  2180  1140   460   470   730   530  1070  1530  1750  2020 R
T  EPA  BURTON  HIVOL    2267   925  2187  1089  2365  1014  1550   593   777  1531  1030   839   753   604   634   685 T
A  BNL  TANNER  HIVOL    1610  2480  3120  3290  2740  4290  2130  4120     -  1270  1070  2430   980  3150   970  3570 A
E  ERT  MULLER  TSP         -  2240     -  3020  3340  4380  3600  5590  1350   970  1850  2040  2150  3190  2640  3990 E

Z MEAN(ALL SAMPLERS)     1716  1624  2222  2027  2564  2734  2365  2861   862  1060  1170  1460  1238  2119  1499  2566    1880   973
   STANDARD DEVIATION     507   856   881  1316   643  1852   872  2390   451   455   478   918   622  1272   893  1514

X MEAN(T,A,E)            1939  1882  2654  2466  2815  3228  2427  3434  1064  1257  1317  1770  1294  2315  1415  2748
   STANDARD DEVIATION     465   837   660  1200   492  1918  1057  2568   405   28,   462   829   750  1482  1074  1799

RATIO TO Z      PFRIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD CV

R  EPA  DZUBAY  MDS-S    0.74  0.52  0.61  0.35  0.71  0.46 •0.92  0.40  0.53  0.44  0.62  0.36  0.86  0.72  1.17  0.79 R 0.64 0.23 35
T  EPA  BURTON  HIVOL    1.32  0.57 •0.98  0.54  0.92  0.37  0.66  0.21  0.90  1.44  0.88  0.58  0.61  0.29  0.42  0.27 T 0.68 0.37 53
A  BNL  TANNER  HIVOL   •0.94  1.53  1.40  1.62 •1.07  1.57  0.90  1.44     -  1.20 •0.91  1.67  0.79  1.49  0.65  1.39 A 1.24 0.33 27
E  ERT  MULLER  TSP         -  1.38     -  1.49  1.30  1.60  1.52  1.95  1.57 •0.92  1.58  1.40  1.74  1.51  1.76  1.56 E 1.52 0.24 16

  MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION    0.30  0.53  0.40  0.65  0.25  0.68  0.37  0.84  0.52  0.43  0.41  0.63  0.50  0.60  0.60  0.59    0.52

REGRESSION VS Z         INTERCEPT     ERROR       SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S     141.429   349.713       0.561      0.177   436.355      0.647
T  EPA  BURTON  HIVOL     910.096   504.164       0.142      0.255   629.071      0.148
A  BNL  TANNER  HIVOL    -680.118   532.221       1.623      0.262   585.282      0.864
E  ERT  MULLER  TSP      -378.121   354.334       1.746      0.179   436.978      0.942
```

```
1                         INTERCOMPARISON STUDY OF SMALL NO3 :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD       1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16       AVG     SD

R  EPA  DZUBAY  MDS-S       400    <50    <50    <50    <50    <50    <50    <50    <50    <50    <50    <50    <50    550    <50    760 R
B  EPA  BURTON  CHAMP       740    355   1184    273    862    315    277    369    699    700    671    545    442    441    405    356 B
U  EPA  BURTON  CHAMP       978    430   1162    538    849    501    360    355    556    796    418    435    429    611    315    357 U
F  ERT  MULLER  RSP        1960   2180  -3770   2180  -1750   2510   1440  -3900    900    770   1240   1380    970  -2220   1170   2660 F

Z MEAN(WITHOUT R)          1226    988   2039    997   1154   1109    692   1541    718    755    776    787    614   1091    630   1124      1015    761
   STANDARD DEVIATION       647   1033   1499   1033    516   1217    649   2043    173     50    421    517    309    982    470   1330

X MEAN(U,F)                1469   1305   2466   1359   1300   1506    900   2128    728    783    829    908    700   1416    743   1509
   STANDARD DEVIATION       694   1237   1844   1161    637   1421    764   2507    243     18    581    668    383   1138    605   1628

RATIO TO Z       PERIOD       1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16       AVG     SD CV

R  EPA  DZUBAY  MDS-S      0.33  <0.05  <0.02  <0.05  <0.04  <0.05  <0.07  <0.03  <0.07  <0.07  <0.06  <0.06  <0.08   0.50  <0.08   0.68 R   0.50   0.18 35
B  EPA  BURTON  CHAMP      0.60   0.36   0.58   0.27   0.75   0.28   0.40   0.24  •0.97   0.93   0.86   0.69   0.72   0.40   0.64   0.32 B   0.56   0.24 43
U  EPA  BURTON  CHAMP      0.80   0.44   0.57   0.54   0.74   0.45   0.52   0.23   0.77   1.05   0.54   0.55   0.70   0.56   0.50   0.32 U   0.58   0.20 34
F  ERT  MULLER  RSP        1.60   2.21   1.85   2.19   1.52   2.26   2.08   2.53  •1.25  •1.02   1.60   1.75   1.58   2.04   1.86   2.37 F   1.86   0.42 22

  MEAN(WITHOUT R)          1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00     1.00
   STANDARD DEVIATION      0.53   1.05   0.74   1.04   0.45   1.10   0.94   1.33   0.24   0.07   0.54   0.66   0.50   0.90   0.75   1.18     0.75

REGRESSION VS Z          INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV.  COR.COEFF.
R  EPA  DZUBAY  MDS-S      0.          0.         0.         0.         0.         0.
B  EPA  BURTON  CHAMP    213.792     170.831      0.321      0.159    229.402      0.476
U  EPA  BURTON  CHAMP    165.610     154.894      0.397      0.144    208.002      0.593
F  ERT  MULLER  RSP     -379.402     307.818      2.282      0.286    413.356      0.906
```

```
1                 INTERCOMPARISON STUDY OF LARGE NO3 :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS        PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

R  EPA  DZUBAY  MDS-S    870   850  1360   710  1810  1250  2180  1140   460   470   730   530  1070   980  1750  1260 R

Z MEAN(ALL SAMPLERS)     870   850  1360   710  1810  1250  2180  1140   460   470   730   530  1070   980  1750  1260   1089    0
   STANDARD DEVIATION      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

X MEAN()                   -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -
   STANDARD DEVIATION      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

RATIO TO Z     PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

R  EPA  DZUBAY  MDS-S *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 *1.00 R 1.00 0.    0

  MEAN(ALL SAMPLERS)    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.     0.

REGRESSION VS Z       INTERCEPT     ERROR     SLOPE     ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S     0.          0.      1.000      0.        0.       1.000
```

```
1                  INTERCOMPARISON STUDY OF TOTAL SO4 ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

R  EPA  DZUBAY  MDS-S 12910 10230 11670 11100 17820 21440 22330 24000 11000  4470 14750 13500 24080 29100 28600 27930 R
P  EPA  RODES   HIVOL 17600 19000 16400 15600 22100 27300 25200 27900 17700  9600 18700 17800-30900 33100 34900 30900 P
T  EPA  BURTON  HIVOL 13650 15360 13080 15250 20540 25480 23330 25960 14890  8290 16500 18200 25200 34150 25700 28800 T
A  BNL  TANNER  HIVOL 13500 11500 11300 12300 16400 21800 20200     -     -  5040 13000 14800 23600 25800 23900 26000 A
E  ERT  MULLER  TSP       - 11000     - 13200 16700 23400 22800     -  9500  4700 14400 16600 25000 29300 28200 26900 E

Z MEAN(ALL SAMPLERS)  14415 13418 13113 13490 18712 23884 22772 25953 13273  6420 15470 16180 25756 30290 28260 28106  19344 3011
   STANDARD DEVIATION  2147  3695  2322  1921  2500  2488  1804  1950  3724  2360  2194  1998  2950  3367  4176  1885

X MEAN(P,T,A,E)       14917 14215 13593 14088 18935 24495 22883 26930 14030  6908 15650 16850 26175 30588 28175 28150
   STANDARD DEVIATION  2325  3738  2588  1594  2829  2401  2063  1372  4167  2417  2491  1526  3229  3811  4818  2173

RATIO TO Z     PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

R  EPA  DZUBAY  MDS-S  0.90  0.76  0.89  0.82  0.95  0.90  0.98  0.93  0.83  0.70  0.95  0.83  0.94  0.96  1.01 •0.99 R 0.90 0.09 10
P  EPA  RODES   HIVOL  1.22  1.42  1.25  1.16  1.18  1.14  1.11  1.08  1.33  1.50  1.21  1.10  1.20  1.09  1.24  1.10 P 1.21 0.12 10
T  EPA  BURTON  HIVOL •0.95  1.15 •1.00  1.13  1.10  1.07 •1.02 •1.00  1.12  1.29  1.07  1.13 •0.98  1.13  0.91 •1.03 T 1.07 0.09  9
A  BNL  TANNER  HIVOL •0.94  0.86  0.86 •0.91  0.88 •0.91  0.89     -     -  0.79  0.84 •0.92 •0.92  0.85  0.85 •0.93 A 0.88 0.04  5
E  ERT  MULLER  TSP       -  0.82     - •0.98  0.89 •0.98 •1.00     -  0.72  0.73  0.93 •1.03 •0.97 •0.97 •1.00 •0.96 E 0.92 0.10 11

  MEAN(ALL SAMPLERS)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.15  0.28  0.18  0.14  0.13  0.10  0.08  0.08  0.28  0.37  0.14  0.12  0.11  0.11  0.15  0.07   0.16

REGRESSION VS Z       INTERCEPT      ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S -2876.984    651.527      1.069      0.032   872.124      0.994
P  EPA  RODES   HIVOL  3072.122   1052.180      1.019      0.051  1408.431      0.983
T  EPA  BURTON  HIVOL  1754.886   1128.762      0.957      0.055  1510.943      0.978
A  BNL  TANNER  HIVOL  -152.720    587.006      0.893      0.029   743.091      0.994
E  ERT  MULLER  TSP   -2362.810    904.203      1.064      0.043  1099.141      0.991
```

```
1
                         INTERCOMPARISON STUDY OF SMALL SO4 :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.
RESULTS          PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16     AVG   SD

R  EPA  DZUBAY  MDS-S   12379   9773  10795  11478  17139  20915  21758  22975  10493   3799  13776  12686  23468  28599  27707  26868 R
O  EPA  RODES    DICOT  11600  11720   8250   4800  16330  21970  21170  23230  10710   4550  11600  15820  23200      -  25260  27730 O
B  EPA  BURTON  CHAMP   14985  14441  13649  13816  22256  26343  22933  26935  11977   7887  16442  14400  28000  32713  29437  28646 B
U  EPA  BURTON  CHAMP   14643  13500  12829  14815  22222  27159  27662  26899  13026   6787  15434  17081  28650  32438  29695  28998 U
F  ERT  MULLER  RSP     14600   9700  10100  10600  16700  24600  22800  13700   7800   4200  12000  13300  21600  25400  24800  25000 F

Z MEAN(ALL SAMPLERS)    13641  11827  11125  11102  18929  24197  23265  22748  10801   5445  13850  14657  24984  29788  27380  27448   18199 2993
  STANDARD DEVIATION     1540   2144   2162   3913   3035   2705   2565   5406   1965   1791   2105   1804   3141   3476   2283   1600

X MEAN(O,U,F)           13614  11640  10393  10072  18417  24576  23877  21276  10512   5179  13011  15400  24483  28919  26585  27243
  STANDARD DEVIATION     1745   1901   2304   5028   3300   2595   3377   6813   2619   1404   2108   1925   3696   4977   2703   2043
RATIO TO Z       PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     .6      AVG   SD CV

R  EPA  DZUBAY  MDS-S    0.91   0.83   0.97   1.03   0.91   0.86   0.94   1.01   0.97   0.70  •0.99   0.87   0.94   0.96   1.01   0.98 R 0.93 0.09  9
O  EPA  RODES    DICOT   0.85  •0.99   0.74   0.43   0.86   0.91   0.91  •1.02  •0.99  •0.84   0.84  •1.08   0.93      -   0.92  •1.01 O 0.89 0.15 17
B  EPA  BURTON  CHAMP    1.10   1.22   1.23   1.24   1.18   1.09  •0.99   1.18   1.11   1.45   1.19  •0.98   1.12   1.10   1.08   1.04 B 1.14 0.11 10
U  EPA  BURTON  CHAMP    1.07   1.14   1.15   1.33   1.17   1.12   1.19   1.18   1.21   1.25   1.11   1.17   1.15   1.09   1.08   1.06 U 1.16 0.07  6
F  ERT  MULLER  RSP      1.07   0.82   0.91  •0.96   0.88  •1.02  •0.98   0.60   0.72   0.77   0.87   0.91   0.86   0.85   0.91   0.91 F 0.88 0.11 13

  MEAN(ALL SAMPLERS)     1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00     1.00
   STANDARD DEVIATION    0.11   0.18   0.19   0.35   0.16   0.11   0.11   0.24   0.18   0.33   0.15   0.12   0.13   0.12   0.08   0.06     0.16
REGRESSION VS Z          INTERCEPT      ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S     -929.696    721.269      0.994      0.037  1069.188    0.991
O  EPA  RODES    DICOT   -2112.424   1331.718      1.031      0.071  1882.892    0.970
B  EPA  BURTON  CHAMP     1956.156    849.885      1.008      0.043  1259.845    0.987
U  EPA  BURTON  CHAMP     1466.196    670.146      1.059      0.034   993.405    0.993
F  ERT  MULLER  RSP       -159.967   1504.520      0.891      0.077  2230.257    0.952
```

```
1                    INTERCOMPARISON STUDY OF LARGE SO4 ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS        PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

R  EPA  DZUBAY  MDS-S    532   453   875   629   682   527   571  1017   506   667   975   570   609   490   888  1060 R
O  EPA  RODES   DICOT    450   200   530  1350  1070   690  1670  1600   200  1840  1440  1310  1880  2320  1070  1030 O

Z MEAN(ALL SAMPLERS)     491   327   703   990   876   609  1121  1309   353  1254  1208   940  1245  1405   979  1045     928  402
   STANDARD DEVIATION     58   179   244   510   274   115   777   412   216   829   329   523   899  1294   129    21

X MEAN(O)                450   200   530  1350  1070   690  1670  1600   200  1840  1440  1310  1880  2320  1070  1030
   STANDARD DEVIATION      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

RATIO TO Z     PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

R  EPA  DZUBAY  MDS-S  1.08  1.39  1.25  0.64  0.78  0.87  0.51  0.78  1.43  0.53  0.81  0.61  0.49  0.35  0.91 •1.01 R 0.84 0.33 39
O  EPA  RODES   DICOT •0.92 •0.61 •0.75 •1.36 •1.22 •1.13  1.49 •1.22 •0.57  1.47 •1.19 •1.39  1.51  1.65 •1.09 •0.99 O 1.16 0.33 28

  MEAN(ALL SAMPLERS)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION  0.12  0.55  0.35  0.52  0.31  0.19  0.69  0.32  0.61  0.66  0.27  0.56  0.72  0.92  0.13  0.02    0.43

REGRESSION VS Z        INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S    463.515   142.678      0.245      0.145   191.696      0.412
O  EPA  RODES   DICOT   -463.515   142.678      1.755      0.145   191.696      0.956
```

```
1                INTERCOMPARISON STUDY OF TOTAL S   ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16    AVG   SD

D EPA DZUBAY     MDS-A    4830   3060      -   3300   5870      -   7660      -   3680      -      -   4400   8220      -   9160      - D
M EPA DZUBAY      TF-M    5230   3930   4300   4550   6380   8370   7870      -   3840   1750   5240   5000   8040  10020   9040   9580 M
N EPA DZUBAY      TF-P    5280   3730   3960   4280   6040   7120   7880   7950   3640   1860   4880   5070   8480      -  10270      - N
R EPA DZUBAY     MDS-S    4540   3350   4130   3690   6040   7330   7560   7380   3650   1820   4820   4880   7680      -   9610      - R
C LBL LOO        DICOT       -      -      -   4819   7313   9062   8954      -   4528   2158   6054   6102   9345  10587  11033  10097 C
L LBL LOO        DICOT    5969   4283   5174   4685   7206   9072   8960      -   4540   2234   5957   6106   9538  10974  10987  10117 L
S LBL LOO        DICOT    5869   4382   5145      -   7186   8592   8868      -   4348   2250      -      -      -  10620  11013  10109 S
G UCD CAHILL     SMDAY       -   2503   2966   3819   5577   7988   7009   9620   3474   1578   3584      -      -      -      -      - G
H UCD CAHILL     TTLF     5027   3120   4093   3847   5582   7183   7555   6919   3949   1055   4980   4654   7174   9513   9079   9307 H
I UCD CAHILL     SFU      4579   2949   3724   3836   8086   7764   7814   8942   4088   1934   4882   5748   7644  10306   7851   7042 I
J FSU HUDSON     LS .2       -      -      -   4620   8309   8699   9915   8874   4418   2502   5971   5418  11064  11933  13235  11709 J
K FSU HUDSON     LS .4       -      -      -   6093   9725  10340-11209  10549   5133   2144   6791   6080  11960  12427  13707  11617 K

Z MEAN(ALL SAMPLERS)      5166   3479   4187   4322   6943   8320   8438   8605   4107   1935   5316   5346   8915  10798  10453   9947   6642 1007
   STANDARD DEVIATION      538    641    724    763   1279    977   1199   1276    493    395    901    636   1566    967   1798   1462

X MEAN(D,M,L,G,I,K)       5152   3345   4041   4381   7141   8707   8420   9704   4126   1928   5291   5467   9080  10932  10149   9589
   STANDARD DEVIATION      607    736    932    983   1563   1039   1504    807    615    271   1202    745   1760   1074   2283   1904

RATIO TO Z       PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16     AVG   SD CV

D EPA DZUBAY     MDS-A    0.94   0.88      -   0.76   0.85      -   0.91      -   0.90      -      -   0.82   0.92      -   0.88      - D 0.87 0.05  6
M EPA DZUBAY      TF-M   •1.01   1.13  •1.03  •1.05   0.92  •1.01   0.93      -   0.94   0.90  •0.99   0.94   0.90   0.93   0.87  •0.96 M 0.97 0.07  7
N EPA DZUBAY      TF-P   •1.02  •1.07  •0.95  •0.99   0.87   0.86   0.93   0.92   0.89  •0.96   0.92  •0.95  •0.95      -  •0.98      - N 0.95 0.06  6
R EPA DZUBAY     MDS-S    0.88  •0.96  •0.99   0.85   0.87   0.88   0.90   0.86   0.89  •0.94   0.91   0.91   0.86      -   0.92      - R 0.90 0.04  4
C LBL LOO        DICOT       -      -      -   1.12  •1.05  •1.09  •1.06      -  •1.10   1.12   1.14   1.14  •1.05  •0.98  •1.06  •1.02 C 1.08 0.05  5
L LBL LOO        DICOT    1.16   1.23   1.24  •1.08  •1.04  •1.09  •1.06      -  •1.11   1.15   1.12   1.14  •1.07  •1.02  •1.05  •1.02 L 1.11 0.07  6
S LBL LOO        DICOT    1.14   1.26   1.23      -  •1.04  •1.03  •1.05      -  •1.06   1.16      -      -      -  •0.98  •1.05  •1.02 S 1.09 0.09  8
G UCD CAHILL     SMDAY       -   0.72   0.71  •0.88   0.80  •0.96   0.83  •1.12   0.85   0.82   0.67      -      -      -      -      - G 0.84 0.13 16
H UCD CAHILL     TTLF    •0.97  •0.90  •0.98  •0.89   0.80  •0.86  •0.90   0.80  •0.96   0.55  •0.94   0.87   0.81  •0.88  •0.87  •0.94 H 0.87 0.10 12
I UCD CAHILL     SFU     •0.89   0.85  •0.89  •0.89   1.17  •0.93  •0.93  •1.04  •1.00  •1.00  •0.92  •1.08   0.86  •0.95   0.75   0.71 I 0.93 0.11 12
J FSU HUDSON     LS .2       -      -      -  •1.07   1.20  •1.05   1.18  •1.03  •1.08   1.29   1.12  •1.01   1.24   1.11   1.27   1.18 J 1.14 0.09  8
K FSU HUDSON     LS .4       -      -      -   1.41   1.40   1.24   1.33   1.23  •1.25  •1.11   1.28   1.14   1.34   1.15   1.31   1.17 K 1.26 0.10  8

  MEAN(ALL SAMPLERS)      1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00    1.00
   STANDARD DEVIATION     0.10   0.18   0.17   0.18   0.18   0.12   0.14   0.15   0.12   0.20   0.17   0.12   0.18   0.09   0.17   0.15    0.15

REGRESSION VS Z           INTERCEPT      ERROR      SLOPE      ERROR   RMS.DEV.  COR.COEFF.
D EPA DZUBAY     MDS-A     -278.785    285.986      0.922      0.042    292.951       0.993
M EPA DZUBAY      TF-M      516.563    232.792      0.874      0.033    345.384       0.991
N EPA DZUBAY      TF-P      147.906    250.244      0.916      0.038    343.608       0.990
R EPA DZUBAY     MDS-S      169.248    148.255      0.866      0.023    203.568       0.996
C LBL LOO        DICOT      622.054    227.655      0.973      0.030    283.779       0.995
L LBL LOO        DICOT      735.700    167.264      0.970      0.024    248.163       0.996
S LBL LOO        DICOT      798.496    228.612      0.943      0.031    305.120       0.995
G UCD CAHILL     SMDAY    -1105.987    695.622      1.063      0.116    821.168       0.956
H UCD CAHILL     TTLF        68.194    283.977      0.865      0.040    422.739       0.986
I UCD CAHILL     SFU        636.936    614.587      0.819      0.086    914.898       0.931
J FSU HUDSON     LS .2     -392.676    539.841      1.196      0.070    673.620       0.981
K FSU HUDSON     LS .4      240.014    555.500      1.227      0.073    693.160       0.981
```

```
1                    INTERCOMPARISON STUDY OF SMALL S   :  NANOGRAMS/CUBIC METER; PERIODS 1-16. MAY 11-18 1977.

RESULTS         PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A   4562  2668  3737  2943  5548     -  7367  5449  3541  1506  4542  4336  7912     -  8951     - D
M  EPA  DZUBAY   TF-M   5009  3572  3894  4182  6019  7901  7661     -  3813  1642  4998  4695  7586  9298  8606  8687 M
N  EPA  DZUBAY   TF-P   4951  3170  3443  3684  5529  6709  7426  6804  3413  1495  4411  4525  7764     -  8612     - N
R  EPA  DZUBAY  MDS-S   4297  3040  3707  3373  5743  6938  7284  6678  3499  1601  4368  4683  7362     -  9234     - R
C  LBL  LOO     DICOT   5336     -     -  4123  6572  8287  8186     -  4131  1795  5225  5571  8475  9532 10125  9019 C
L  LBL  LOO     DICOT   5308  3518  4309  3945  6430  8270  8172     -  4100  1819  5150  5468  8617  9851  9998  8969 L
S  LBL  LOO     DICOT   5244  3693  4274     -  6448  7859  8119     -  3987  1825  5261  5514     -  9577 10146  9094 S
G  UCD  CAHILL  SMDAY   4310  2500  2940  3800  5570  7970  7000  9600  3470  1580  3560     -     -     -     -     - G
I  UCD  CAHILL  SFU     3769  2693  3491  3481  7557  7263  7225  8148  3801  1744  4473  5433  6950  9314  7375  5833 I
Q  STL  DEL/ED  2MASS   1900  1210  1270  -970 -1430 -1150 -1250  1010  -860  1130  1610 -1500 -2090 -1390 -1920  3130 Q

Z MEAN(WITHOUT Q)       4754  3107  3724  3691  6157  7650  7604  7336  3751  1667  4665  5028  7809  9514  9131  8320   5869  626
   STANDARD DEVIATION    548   458   451   416   670   603   451  1586   280   132   552   514   591   226   959  1399

X MEAN(D,M,L,G,I)       4592  2990  3674  3670  6225  7851  7485  7732  3745  1658  4545  4983  7766  9488  8733  7830
   STANDARD DEVIATION    601   512   507   479   829   423   453  2106   251   125   622   560   694   315  1081  1735

RATIO TO Z      PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A  •0.96  0.86 •1.00  0.80  0.90     - •0.97  0.74  0.94  0.90 •0.97  0.86 •1.01     - •0.98     - D 0.92 0.08  9
M  EPA  DZUBAY   TF-M  •1.05  1.15 •1.05  1.13 •0.98 •1.03 •1.01     - •1.02 •0.99  1.07  0.93 •0.97 •0.98  0.94 •1.04 M 1.02 0.06  6
N  EPA  DZUBAY   TF-P  •1.04 •1.02  0.92 •1.00  0.90  0.88 •0.98  0.93  0.91  0.90 •0.95  0.90 •0.99     -  0.94     - N 0.95 0.05  5
R  EPA  DZUBAY  MDS-S   0.90 •0.98 •1.00  0.91  0.93  0.91 •0.96  0.91  0.93 •0.96  0.94  0.93  0.94     - •1.01     - R 0.94 0.03  4
C  LBL  LOO     DICOT   1.12     -     -  1.12 •1.07 •1.08 •1.08     - •1.10 •1.08  1.12 •1.11 •1.09 •1.00 •1.11 •1.08 C 1.09 0.03  3
L  LBL  LOO     DICOT   1.12  1.13  1.16 •1.07 •1.04 •1.08 •1.08     - •1.09 •1.09 •1.10 •1.09 •1.10 •1.04 •1.10 •1.08 L 1.09 0.03  3
S  LBL  LOO     DICOT  •1.10  1.19  1.15     - •1.05 •1.03 •1.07     - •1.06 •1.09  1.13 •1.10     - •1.01  1.11 •1.09 S 1.09 0.05  5
G  UCD  CAHILL  SMDAY  •0.91  0.81  0.79 •1.03 •0.90 •1.04 •0.92  1.31 •0.93 •0.95  0.76     -     -     -     -     - G 0.94 0.15 16
I  UCD  CAHILL  SFU     0.79  0.87 •0.94 •0.94  1.23 •0.95 •0.95 •1.11 •1.01 •1.05 •0.96 •1.08 •0.89 •0.98  0.81  0.70 I 0.95 0.13 14
Q  STL  DEL/ED  2MASS   0.40  0.39  0.34  0.26  0.23  0.15  0.16  0.14  0.23  0.68  0.35  0.30  0.27  0.15  0.21  0.38 Q 0.29 0.14 47

  MEAN(WITHOUT Q)       1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION   0.12  0.15  0.12  0.11  0.11  0.08  0.06  0.22  0.08  0.08  0.12  0.10  0.08  0.02  0.11  0.17   0.11

REGRESSION VS Z        INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A   -219.166   396.721      0.963      0.070   530.327     0.972
M  EPA  DZUBAY   TF-M    387.016   195.029      0.944      0.031   284.104     0.993
N  EPA  DZUBAY   TF-P     62.634   207.518      0.934      0.036   281.747     0.991
R  EPA  DZUBAY  MDS-S    -95.827   167.455      0.962      0.029   227.354     0.995
C  LBL  LOO     DICOT    266.537   189.194      1.040      0.029   240.356     0.996
L  LBL  LOO     DICOT    195.124   114.091      1.051      0.018   166.201     0.998
S  LBL  LOO     DICOT    325.002   196.595      1.023      0.031   270.438     0.995
G  UCD  CAHILL  SMDAY  -1002.408   731.934      1.170      0.139   880.238     0.942
I  UCD  CAHILL  SFU      449.415   610.244      0.866      0.097   890.555     0.923
Q  STL  DEL/ED  2MASS      0.         0.        0.         0.        0.         0.
```

```
1                 INTERCOMPARISON STUDY OF LARGE S   :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD

D EPA  DZUBAY  MDS-A       267   391     -   356   327     -   290     -   139     -     -   257   307     -   212   424 D
M EPA  DZUBAY   TF-M       222   360   393   367   362   470   212     -    26   113   240   299   450   716   438   896 M
N EPA  DZUBAY   TF-P       329   559   518   601   507   637   447  1148   231   363   469   546   714  1000  1655  1072 N
R EPA  DZUBAY  MDS-S       239   316   427   319   293   385   280   701   156   219   450   192   319   484   374   537 R
C LBL  LOO     DICOT         -     -     -   696   741   775   768     -   797   363   799   531   870  1055   908  1078 C
L LBL  LOO     DICOT       661   765   865   740   776   802   788     -   440   415   807   638   921  1123   989  1148 L
S LBL  LOO     DICOT       625   689   871     -   738   733   749     -   361   425     -     -     -  1043   867  1015 S
G UCD  CAHILL  SMDAY         -     -    23    26     4    18     -     8     -     -    23     -     -     -     -     - G
I UCD  CAHILL  SFU         810   256   233   355   529   501   589   794   287   190   409   315   694   992   476  1209 I

Z MEAN(WITHOUT G)          450   477   551   491   534   615   515   881   255   298   529   397   611   916   740   922     574   237
   STANDARD DEVIATION      241   196   262   182   198   164   239   236   143   123   227   171   253   230   466   289

X MEAN(D,M,L,I)            490   443   497   455   499   591   470   794   223   239   485   377   593   944   529   919
   STANDARD DEVIATION      291   222   329   190   205   183   267     0   180   157   291   176   271   208   328   357

RATIO TO Z      PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD CV

D EPA  DZUBAY  MDS-A      0.59 •0.82     - •0.73  0.61     -  0.56     -  0.55     -     - •0.65  0.50     -  0.29  0.46 D  0.58  0.15 25
M EPA  DZUBAY   TF-M      0.49 •0.76  0.71 •0.75  0.68 •0.76  0.41     -  0.10  0.38  0.45 •0.75  0.74 •0.78  0.59 •0.97 M  0.62  0.22 35
N EFA  DZUBAY   TF-P      0.73 •1.17 •0.94 •1.23 •0.95 •1.04 •0.87 •1.30 •0.91 •1.22 •0.89 •1.38 •1.17 •1.09  2.24 •1.16 N  1.14  0.34 30
R EPA  DZUBAY  MDS-S      0.53  0.66 •0.78  0.65  0.55 •0.63  0.54 •0.80 •0.61 •0.73 •0.85  0.48  0.52  0.53  0.51  0.58 R  0.62  0.11 18
C LBL  LOO     DICOT         -     -     -  1.42  1.39  1.26  1.49     -  1.56  1.22  1.51  1.34  1.42  1.15  1.23  1.17 C  1.35  0.14 10
L LBL  LOO     DICOT      1.47  1.61  1.57  1.51  1.45  1.31  1.53     -  1.73  1.39  1.53  1.61  1.51  1.23  1.34  1.24 L  1.47  0.14 10
S LBL  LOO     DICOT      1.39  1.45  1.58     -  1.38  1.19  1.45     -  1.42  1.43     -     -     -  1.14  1.17 •1.10 S  1.34  0.16 12
G UCD  CAHILL  SMDAY         -     -  0.04  0.05  0.01  0.03     -  0.01     -     -  0.04     -     -     -     -     - G  0.03  0.02 62
I UCD  CAHILL  SFU        1.80  0.54  0.42  0.72 •0.99 •0.82 •1.14 •0.90 •1.13  0.64  0.77  0.79 •1.14 •1.08  0.64 •1.31 I  0.93  0.34 37

  MEAN(WITHOUT G)         1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00     1.00
   STANDARD DEVIATION     0.54  0.41  0.48  0.37  0.37  0.27  0.46  0.27  0.56  0.41  0.43  0.43  0.41  0.25  0.63  0.31     0.41

REGRESSION VS Z         INTERCEPT     ERROR     SLOPE     ERROR  RMS.DEV. COR.COEFF.
D EPA  DZUBAY  MDS-A      162.482    76.598     0.249     0.135    74.998     0.547
M EPA  DZUBAY   TF-M     -222.130    65.619     1.072     0.112    80.428     0.935
N EPA  DZUBAY   TF-P     -170.241   175.854     1.472     0.290   226.894     0.805
R EPA  DZUBAY  MDS-S        9.778    56.473     0.603     0.093    72.863     0.866
C LBL  LOO     DICOT      159.077    54.417     1.037     0.090    63.244     0.964
L LBL  LOO     DICOT      206.966    43.445     1.057     0.074    53.250     0.969
S LBL  LOO     DICOT      205.820    62.598     0.933     0.103    71.126     0.949
G UCD  CAHILL  SMDAY       0.         0.        C.        0.        0.         0.
I UCD  CAHILL  SFU       -113.287   145.254     1.138     0.240   187.413     0.786
```

```
1                  INTERCOMPARISON STUDY OF TOTAL S & SO4;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS            PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

R  EPA  DZUBAY  MDS-S 12910 10230 11670 11100 17820 21440 22330 24000 11000  4470 14750 13500 24080 29100 28600 27930 R
P  EPA  RODES   HIVOL 17600 19000 16400 15600 22100 27300 25200 27900 17700  9600 18700 17800 30900 33100 34900 30900 P
T  EPA  BURTON  HIVOL 13850 15360 13080 15250 20540 25480 23330 25960 14890  8290 16500 18200 25200 34150 25700 28800 T
A  BNL  TANNER  HIVOL 13500 11500 11300 12300 16400 21800 20200     -     -  5040 13000 14800 23600 25800 23900 26000 A
E  ERT  MULLER  TSP       - 11000     - 13200 16700 23400 22800     -  9500  4700 14400 16600 25000 29300 28200 26900 E
D' EPA  DZUBAY  MDS-A 14490  9180     -  9900 17610     - 22980     - 11040     -     - 13200 24660     - 27480     - D
M' EPA  DZUBAY   TF-M 15690 11790 12900 13850 19140 25110 23610     - 11520  5250 15720 15000 24120 30060 27120 28740 M
N' EPA  DZUBAY   TF-P 15840 11190 11880 12840 18120 21360 23640 23850 10920  5580 14640 15210 25440     - 30810     - N
R' EPA  DZUBAY  MDS-S 13620 10050 12390 11070 18120 21990 22680 22140 10950  5460 14460 14640 23040     - 28830     - R
C' LBL  LOO     DICOT     -     -     - 14457 21939 27186 26862     - 13584  6474 18162 18306 28035 31761 33099 30291 C
L' LBL  LOO     DICOT 17907 12849 15522 14055 21618 27216 26880     - 13620  6702 17871 18318 28614 32922 32961 30351 L
S' LBL  LOO     DICOT 17607 13146 15435     - 21558 25776 26604     - 13044  6750     -     -     - 31860 33039 30327 S
G' UCD  CAHILL  SMDAY     -  7509  8898 11457 16731 23964 21027 28860 10422  4734 10752     -     -     -     -     - G
H' UCD  CAHILL  TTLF  15081  9360 12279 11541 16746 21549 22665 20757 11847  3165 14940 13962 21522 28539 27237 27921 H
I' UCD  CAHILL  SFU   13737  8847 11172 11508 24258 23292 23442 26826 12264  5802 14646 17244 22932 30918 23553 21126 I
J' FSU  HUDSON  LS .2     -     -     - 13860 24927 26097 29745 26622 13254  7506 17913 16254 33192 35799 39705 35127 J
K' FSU  HUDSON  LS .4     -     -     - 18279 29175 31020 33627 31647 15399  6432 20373 18240 35880 37281 41121 34851 K

Z MEAN(ALL SAMPLERS)  15136 11501 12744 13129 20206 24624 24566 25856 12560  5997 15708 16085 26414 31584 30391 29174  19735 3095
   STANDARD DEVIATION  1788  2945  2133  2130  3560  2765  3336  3258  2136  1583  2475  1867  4112  3134  5124  3629

X MEAN(PTAEDMLGIK)    15225 11893 12753 13520 20427 25398 24310 28239 12928  6283 15774 16600 26767 31691 29437 28459
   STANDARD DEVIATION  1882  3540  2600  2433  4066  2785  3773  2197  2675  1695  2973  1851  4262  3474  5796  4015

RATIO TO Z         PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

R  EPA  DZUBAY  MDS-S  0.85  0.89  0.92  0.85  0.88  0.87  0.91  0.93  0.88  0.75  0.93  0.84  0.91  0.92  0.94  0.96 R 0.89 0.05  6
P  EPA  RODES   HIVOL  1.16  1.65  1.29  1.19  1.09  1.11  1.03  1.08  1.41  1.60  1.18  1.11  1.17  1.05  1.15  1.06 P 1.21 0.19 16
T  EPA  BURTON  HIVOL  0.90  1.34 *1.03  1.16 *1.02  1.04  0.95 *1.00  1.19  1.38 *1.05  1.13  0.95  1.08  0.85 *0.99 T 1.07 0.15 14
A  BNL  TANNER  HIVOL  0.89 *1.00  0.89 *0.94  0.81  0.89  0.82     -     -  0.84  0.82 *0.92  0.89  0.82  0.79  0.89 A 0.87 0.06  7
E  ERT  MULLER  TSP       - *0.96     - *1.01  0.83 *0.95  0.93     -  0.76  0.78  0.91 *1.03  0.95  0.93  0.93  0.92 E 0.91 0.08  9
D' EPA  DZUBAY  MDS-A *0.96  0.80     -  0.75  0.87     -  0.94     -  0.88     -     -  0.82  0.93     -  0.90     - D 0.87 0.07  8
M' EPA  DZUBAY   TF-M *1.04 *1.03 *1.01 *1.04 *0.95 *1.02 *0.96     -  0.92  0.88 *1.00  0.93  0.91 *0.95  0.89 *0.99 M 0.97 0.05  6
N' EPA  DZUBAY   TF-P *1.05 *0.97  0.93 *0.98  0.90  0.87 *0.96  0.92  0.87 *0.93  0.93 *0.95 *0.96     - *1.01     - N 0.95 0.05  5
R' EPA  DZUBAY  MDS-S  0.90  0.87 *0.97  0.84  0.90  0.89  0.92  0.86  0.87  0.91  0.92  0.91  0.87     - *0.95     - R 0.90 0.04  4
C' LBL  LOO     DICOT     -     -     - *1.10 *1.09 *1.10 *1.09     - *1.08 *1.08  1.15  1.14 *1.06 *1.01 *1.09 *1.04 C 1.09 0.04  4
L' LBL  LOO     DICOT  1.18  1.12  1.22 *1.07 *1.07 *1.11 *1.09     - *1.08  1.12  1.13  1.14 *1.08 *1.04 *1.08 *1.04 L 1.11 0.05  4
S' LBL  LOO     DICOT  1.16  1.14  1.21     - *1.07 *1.05 *1.08     - *1.04  1.13     -     -     - *1.01 *1.09 *1.04 S 1.09 0.06  6
G' UCD  CAHILL  SMDAY     -  0.65  0.70  0.87  0.83 *0.97  0.86 *1.12  0.83  0.79  0.68     -     -     -     -     - G 0.83 0.14 17
H' UCD  CAHILL  TTLF  *1.00  0.81 *0.96 *0.88  0.83 *0.88 *0.92  0.80 *0.94  0.53 *0.95  0.87  0.82 *0.90 *0.90 *0.96 H 0.87 0.11 12
I' UCD  CAHILL  SFU   *0.91  0.77 *0.88  0.88  1.20 *0.95 *0.95 *1.04 *0.98 *0.97 *0.93 *1.07  0.87 *0.98  0.78  0.72 I 0.93 0.12 13
J' FSU  HUDSON  LS .2     -     -     - *1.06  1.23 *1.06  1.21 *1.03 *1.06  1.25  1.13 *1.01  1.26  1.13  1.31  1.20 J 1.15 0.10  9
K' FSU  HUDSON  LS .4     -     -     -  1.39  1.44  1.26  1.37  1.22 *1.23 *1.07  1.29  1.13  1.36  1.18  1.35  1.19 K 1.27 0.11  9

  MEAN(ALL SAMPLERS)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.12  0.26  0.17  0.16  0.18  0.11  0.14  0.13  0.17  0.26  0.16  0.12  0.16  0.10  0.17  0.12   0.16

REGRESSION VS Z       INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S -1340.955   408.111      0.970      0.019   586.391      0.997
P  EPA  RODES   HIVOL  4710.783  1138.617      0.916      0.054  1636.014      0.977
T  EPA  BURTON  HIVOL  3366.495  1266.601      0.857      0.060  1819.908      0.967
A  BNL  TANNER  HIVOL  1269.371   757.087      0.798      0.036  1028.457      0.988
E  ERT  MULLER  TSP    -524.349   846.341      0.948      0.039  1114.792      0.991
D' EPA  DZUBAY  MDS-A -1995.823   925.858      0.991      0.046   895.734      0.992
M' EPA  DZUBAY   TF-M   764.544   669.016      0.924      0.032   956.143      0.992
N' EPA  DZUBAY   TF-P  -314.710   792.290      0.964      0.041  1046.564      0.989
R' EPA  DZUBAY  MDS-S  -191.689   535.412      0.910      0.028   707.245      0.995
C' LBL  LOO     DICOT  1231.775   702.555      1.019      0.032   852.887      0.995
L' LBL  LOO     DICOT  1357.877   503.288      1.025      0.024   719.288      0.996
S' LBL  LOO     DICOT  1545.210   701.902      0.998      0.033   902.897      0.995
G' UCD  CAHILL  SMDAY -4348.720  2015.929      1.125      0.113  2279.568      0.982
H' UCD  CAHILL  TTLF   -483.473   933.408      0.908      0.044  1341.161      0.984
I' UCD  CAHILL  SFU    1246.329  1921.996      0.860      0.091  2761.608      0.930
J' FSU  HUDSON  LS .2 -1817.050  1829.081      1.243      0.081  2225.518      0.977
K' FSU  HUDSON  LS .4    14.665  1805.785      1.278      0.080  2197.173      0.979
```

```
:
                         INTERCOMPARISON STUDY OF SMALL S & SO4;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.
RESULTS           PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD
R  EPA  DZUBAY  MDS-S  12379  9773 10795 11478 17139 20915 21758 22975 10493  3799 13776 12686 23468 28599 27707 26868 R
O  EPA  RODES   DICOT  11600 11720  8250  4800 16330 21970 21170 23230 10710  4550 11600 15820 23200     - 25260 27730 O
B  EPA  BURTON  CHAMP  14905 14441 13649 13816 22256 26343 22933 26935 11977  7887 16442 14400 28000 32713 29437 28646 B
U  EPA  BURTON  CHAMP  14643 13500 12829 14815 22222 27159 27662 26899 13026  6787 15434 17081 28650 32438 29695 28998 U
F  ERT  MULLER  RSP    14600  3700 10100 10600 16700 24600 22800 13700  7200  4200 12000 13300 21600 25400 24800 25000 F
D' EPA  DZUBAY  MDS-A  13686  8004 11211  8829 16644     - 22101 16347 10623  4518 13626 13008 23736     - 26853     - D
M' EPA  DZUBAY   TF-M  15027 10716 11682 12546 18057 23703 22083     - 11439  4926 14994 14085 22758 27894 25818 26061 M
N' EPA  DZUBAY   TF-P  14853  9510 10329 11052 16587 20127 22278 20412 10239  4485 13233 13575 23292     - 25836     - N
R' EPA  DZUBAY  MDS-S  12891  9120 11121 10119 17229 20814 21852 20034 10497  4803 13104 14049 22086     - 27702     - R
C' LBL  LOO     DICOT  16008     -     - 12369 19716 24861 24558     - 12393  5385 15675 16713 25425 28596 30375 27057 C
L' LBL  LOO     DICOT  15924 10554 12927 11835 19290 24810 24516     - 12300  5457 15450 16404 25851 29553 29994 26907 L
S' LBL  LOO     DICOT  15732 11079 12822     - 19344 23577 24357     - 11961  5475 15783 16542     - 28731 30438 27282 S
G' UCD  CAHILL  SMDAY  12930  7500  8820 11400 16710 23910 21000 28800 10410  4740 10680     -     -     -     -     - G
I' UCD  CAHILL  SFU    11307  8079 10473 10443 22671 21789 21675 24444 11403  5232 13419 16299 20850 27942 22125 17499 I
Q' STL  DEL/ED  2MASS   5700  3630  3810  2910  4290  3450  3750  3030  2580  3390  4830  4500  6270  4170  5760  9390 Q

Z MEAN(ALL SAMPLERS)   14040 10284 11154 11085 18635 23429 22975 22378 11091  5160 13944 14920 24076 29096 27388 26205  17866 2392
   STANDARD DEVIATION   1577  2060  1620  2452  2318  2178  1790  4817  1294  1063  1749  1587  2438  2278  2563  3269

X MEAN(OUFDMLGI)       13715  9972 10787 10659 18578 23992 22988 22237 10964  5051 13400 15142 23806 28645 26364 25366
   STANDARD DEVIATION   1653  2071  1716  2940  2581  1830  2203  5971  1556   809  1833  1644  2668  2588  2782  4091

RATIO TO Z        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV
R  EPA  DZUBAY  MDS-S   0.88  0.95  0.97  1.04  0.92  0.89  0.95  1.03  0.95  0.74  0.99  0.85  0.98  0.98  1.01  1.03 R 0.95 0.08  8
O  EPA  RODES   DICOT   0.83 *1.14  0.74  0.43  0.88 *0.94  0.92 *1.04 *0.97 *0.88  0.83 *1.06 *0.96     -  0.92 *1.06 O 0.91 0.17 18
B  EPA  BURTON  CHAMP   1.07  1.40  1.22  1.25  1.19  1.12 *1.00  1.20  1.08  1.53  1.18 *0.97  1.16  1.12  1.08  1.09 B 1.17 0.14 12
U  EPA  BURTON  CHAMP  *1.04  1.31  1.15  1.34  1.19  1.16  1.20  1.20  1.17  1.32  1.11  1.15  1.1'  1.12  1.08  1.11 U 1.18 0.08  7
F  ERT  MULLER  RSP    *1.04  0.94  0.91 *0.96  0.90 *1.05 *0.99  0.61  0.70  0.81  0.86  0.89  0.50  0.87  0.91 *0.95 F 0.89 0.11 13
D' EPA  DZUBAY  MDS-A  *0.98  0.78 *1.01  0.80  0.89     - *0.96  0.73 *0.96  0.88 *0.98  0.87 *0.99     - *0.98     - D 0.91 0.09 10
M' EPA  DZUBAY   TF-M   1.07 *1.04 *1.05  1.13 *0.97 *1.01 *1.00     - *1.03 *0.95  1.08  0.94 *0.95 *0.96  0.94 *0.99 M 1.01 0.06  6
N' EPA  DZUBAY   TF-P  *1.06  0.93  0.93 *1.00  0.89  0.86 *0.97  0.91  0.92  0.87 *0.95  0.91 *0.97     -  0.94     - N 0.94 0.05  6
R' EPA  DZUBAY  MDS-S   0.92  0.89 *1.00  0.91  0.92  0.89 *0.95  0.90 *0.95  0.93  0.94  0.94  0.92     - *1.01     - R 0.93 0.04  4
C' LBL  LOO     DICOT   1.14     -     -  1.12 *1.06 *1.06 *1.07     -  1.12 *1.04  1.12  1.12 *1.06 *0.98 *1.11 *1.03 C 1.08 0.05  4
L' LBL  LOO     DICOT   1.13 *1.03  1.16 *1.07 *1.04 *1.06 *1.07     - *1.11 *1.06 *1.11 *1.10 *1.07 *1.02 *1.10 *1.03 L 1.08 0.04  4
S' LBL  LOO     DICOT   1.12 *1.08  1.15     - *1.04 *1.01 *1.06     - *1.08 *1.06  1.13 *1.11     - *0.99  1.11 *1.04 S 1.08 0.05  5
G' UCD  CAHILL  SMDAY  *0.92  0.73  0.79 *1.03 *0.90 *1.02 *0.91  1.29 *0.94 *0.92  0.77     -     -     -     -     - G 0.93 0.15 16
I' UCD  CAHILL  SFU     0.81  0.79 *0.94 *0.94  1.22 *0.93 *0.94 *1.09 *1.03 *1.01 *0.96 *1.09  0.87 *0.96  0.81  0.67 I 0.94 0.14 14
Q' STL  DEL/ED  2MASS   0.41  0.35  0.34  0.26  0.23  0.15  0.16  0.14  0.23  0.66  0.35  0.30  0.26  0.14  0.21  0.36 Q 0.28 0.13 46

  MEAN(ALL SAMPLERS)    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION   0.11  0.20  0.15  0.22  0.12  0.09  0.08  0.22  0.12  0.21  0.13  0.11  0.10  0.08  0.09  0.13   0.13

REGRESSION VS Z          INTERCEPT      ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
R  EPA  DZUBAY  MDS-S    -1131.690    673.419      1.024      0.035   989.899      0.992
O  EPA  RODES   DICOT    -2161.459   1484.731      1.053      0.081  2081.730      0.964
B  EPA  BURTON  CHAMP     1879.978   1024.562      1.031      0.053  1506.064      0.982
U  EPA  BURTON  CHAMP     1309.138    746.840      1.088      0.039  1097.825      0.991
F  ERT  MULLER  RSP       -308.132   1526.507      0.916      0.079  2243.904      0.951
D' EPA  DZUBAY  MDS-A     -688.907   1249.297      0.955      0.073  1664.961      0.969
M' EPA  DZUBAY   TF-M     1271.471    706.292      0.925      0.027   742.921      0.995
N' EPA  DZUBAY   TF-P      179.267    643.675      0.925      0.036   873.048      0.991
R' EPA  DZUBAY  MDS-S     -277.456    580.752      0.951      0.033   787.702      0.993
C' LBL  LOO     DICOT     1248.835    677.192      1.004      0.034   876.799      0.994
L' LBL  LOO     DICOT      768.559    458.787      1.026      0.024   673.212      0.996
S' LBL  LOO     DICOT     1106.434    665.830      1.002      0.035   920.581      0.993
G' UCD  CAHILL  SMDAY    -3103.357   2156.711      1.164      0.135  2586.929      0.945
I' UCD  CAHILL  SFU       1603.787   1903.345      0.840      0.099  2797.840      0.915
Q' STL  DEL/ED  2MASS           0.          0.        0.         0.        0.          0.
```

```
1
                        INTERCOMPARISON STUDY OF LARGE S & SO4:  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.
 RESULTS             PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG    SD

 R  EPA  DZUBAY  MDS-S        532   453   875   629   682   527   571  1017   506   667   975   570   609   490   888  1060 R
 O  EPA  RODES   DICOT        450   200   530  1350  1070   690  1670  1600   200  1840  1440  1310  1880  2320  1070  1030 O
 D' EPA  DZUBAY  MDS-A        801  1173     -  1068   981     -   870     -   417     -     -   771   921     -   636  1272 D
 M' EPA  DZUBAY   TF-M        666  1080  1179  1101  1086  1410   636     -    78   339   720   897  1350  2148  1314  2688 M
 N' EPA  DZUBAY   TF-P        987  1677  1554  1803  1521  1911  1341  3444   693  1089  1407  1638  2142  3000  4965  3216 N
 R' EPA  DZUBAY  MDS-S        717   948  1281   957   879  1155   840  2103   468   653  1350   576   957  1452  1122  1611 R
 C' LBL  LOO     DICOT          -     -     -  2088  2223  2325  2304     -  1191  1089  2397  1593  2610  3165  2724  3234 C
 L' LBL  LOO     DICOT       1983  2295  2595  2220  2328  2406  2364     -  1320  1245  2421  1914  2763  3369  2967  3444 L
 S' LBL  LOO     DICOT       1875  2067  2613     -  2214  2199  2247     -  1083  1275     -     -     -  3129  2601  3045 S
 G' UCD  CAHILL  SMDAY          -     -    69    78    12    54     -    24     -     -    69     -     -     -     -     - G
 I' UCD  CAHILL  SFU         2430   768   699  1065  1587  1503  1767  2382   861   570  1227   945  2082  2976  1428  3627 I

 Z MEAN(WITHOUT G)           1160  1185  1416  1365  1457  1570  1461  2109   682   975  1492  1135  1702  2450  1972  2423   1534   755
     STANDARD DEVIATION       733   707   803   548   614   693   707   909   422   461   615   495   775   958  1339  1055

 X MEAN(ODMLGI)              1266  1103  1251  1361  1410  1502  1461  1991   575   999  1452  1167  1799  2703  1483  2412
     STANDARD DEVIATION       882   767   937   495   565   704   704   553   512   680   713   463   705   569   883  1207

 RATIO TO Z          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

 R  EPA  DZUBAY  MDS-S       0.46  0.38  0.62  0.46  0.47  0.34  0.39  0.48  0.74  0.68  0.65  0.50  0.36  0.20  0.45  0.44 R 0.48 0.14 29
 O  EPA  RODES   DICOT       0.39  0.17  0.37 *0.99 *0.73  0.44 *1.14  0.76  0.29  1.89 *0.97 *1.15 *1.11 *0.95  0.54  0.43 O 0.77 0.44 57
 D' EPA  DZUBAY  MDS-A      *0.69 *0.99     - *0.78 *0.67     - *0.60     - *0.61     -     - *0.68  0.54     -  0.32  0.53 D 0.64 0.18 27
 M' EPA  DZUBAY   TF-M       0.57 *0.91 *0.83 *0.81 *0.75 *0.90  0.44     -  0.11  0.35  0.48 *0.79 *0.79 *0.88  0.67 *1.11 M 0.69 0.26 37
 N' EPA  DZUBAY   TF-P      *0.85 *1.42 *1.10 *1.32 *1.04 *1.22 *0.92  1.63 *1.02 *1.12 *0.94 *1.44 *1.26 *1.22  2.52 *1.33 N 1.27 0.39 31
 R' EPA  DZUBAY  MDS-S       0.62 *0.80 *0.91 *0.70  0.60 *0.74  0.58 *1.00 *0.69  0.67 *0.91  0.51  0.56  0.59  0.57 *0.67 R 0.69 0.14 20
 C' LBL  LOO     DICOT          -     -     -  1.53  1.53  1.48  1.58     -  1.75  1.12  1.61  1.40  1.53  1.29  1.38  1.34 C 1.46 0.17 11
 L' LBL  LOO     DICOT       1.71  1.94  1.83  1.63  1.60  1.53  1.62     -  1.94  1.28  1.62  1.69  1.62  1.38  1.51  1.42 L 1.62 0.19 12
 S' LBL  LOO     DICOT       1.62  1.75  1.85     -  1.52  1.40  1.54     -  1.59  1.31     -     -     -  1.28  1.32  1.26 S 1.49 0.20 13
 G' UCD  CAHILL  SMDAY          -     -  0.05  0.06  0.01  0.03     -  0.01     -     -  0.05     -     -     -     -     - G 0.03 0.02 59
 I' UCD  CAHILL  SFU         2.09  0.65  0.49  0.78 *1.09 *0.96 *1.21 *1.13 *1.26  0.59 *0.82 *0.83 *1.22 *1.22  0.72  1.50 I 1.04 0.40 39

 MEAN(WITHOUT G)             1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.0C  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
  STANDARD DEVIATION         0.63  0.60  0.57  0.40  0.42  0.44  0.48  0.43  0.62  0.47  0.41  0.44  0.46  0.39  0.68  0.44   0.49

 REGRESSION VS Z          INTERCEPT      ERROR       SLOPE      ERROR  RMS.DEV.  COR.COEFF.
 R  EPA  DZUBAY  MDS-S      380.904    153.040       0.202      0.095   182.991    0.493
 O  EPA  RODES   DICOT      234.300    476.936       0.607      0.297   570.277    0.480
 D' EPA  DZUBAY  MDS-A      493.099    238.758       0.274      0.157   228.562    0.526
 M' EPA  DZUBAY   TF-M     -727.436    235.814       1.230      0.150   274.872    0.915
 N' EPA  DZUBAY   TF-P     -715.568    576.008       1.786      0.358   688.738    0.800
 R' EPA  DZUBAY  MDS-S        3.762    211.428       0.693      0.131   252.807    0.815
 C' LBL  LOO     DICOT      317.740    184.238       1.238      0.113   197.606    0.961
 L' LBL  LOO     DICOT      550.963    167.923       1.220      0.107   195.737    0.953
 S' LBL  LOO     DICOT      586.030    223.026       1.069      0.138   245.142    0.932
 G' UCD  CAHILL  SMDAY           0.         0.       0.         0.         0.       0.
 I' UCD  CAHILL  SFU       -523.314    466.181       1.397      0.290   557.417    0.790
```

```
1                       INTERCOMPARISON STUDY OF TOTAL SI  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS            PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A      5400  6460     -  6380  8480     -  7970     -  2450     -     -  6240  7330     - 12320  7060 D
M  EPA  DZUBAY   TF-M      4170  8970  7590  9080 11040  8540  9280     -  1080  5930  4540  6620  8530  7830     -  5900 M
N  EPA  DZUBAY   TF-P      3570  9430  8895  8730     -  9010  9890  9200  2220  8930  3730  7710  9520  9180 14220  8270 N
R  EPA  DZUBAY  MDS-S      5290  5730  6940  5680  7090  6180  7610  6370  2330  6000  7250  5470  6750  6720 11670  6280 R
C  LBL  LOO     DICOT         -     -     - 11916 13869 11685 12696     -  3726  8148 12998 11148 13803 10803 18069 10845 C
L  LBL  LOO     DICOT     11878 12142 12037 12521 13896 12278 13934     -  4209 10799 13580 11215 14276 12044 18474 11927 L
S  LBL  LOO     DICOT     14171 13370 16454     - 16438 12614 15941     -  4720 11565     -     -     - 13107 19122 12213 S
G  UCD  CAHILL  SMDAY         -  6137  5376  8330  7076  6436  7465  9898  2962  4773  5243     -     -     -     -     - G
H  UCD  CAHILL  TTLF      10070  8817 12324  8810 13407  9116 12893 10341  4251  7911  8401  9774 13368  9331 17203  9110 H
I  UCD  CAHILL  SFU        3645  6252  4155  5968  9115  6411  7589  9406  3248  4344   247  5967  7879 10200  6416  8376 I
J  FSU  HUDSON  LS .2         -     -     - 12703 22554 13145 22850 13135 -9250 10287 12816  9152 16780 12480 28144 13000 J
K  FSU  HUDSON  LS .4         -     -     - 14930 21200 12580 19870 12675  6814  8180 16790 10313 19350 13750 29934 13570 K

Z MEAN(ALL SAMPLERS)       7274  8590  9221  9548 13106  9818 12332 10146  4003  7897  9260  8361 11759 10545 17557  9686    9944 3640
   STANDARD DEVIATION      4150  2752  4111  3070  5304  2741  5101  2278  2148  2422  4470  2221  4361  2318  7198  2751

X MEAN(D,M,L,G,I,K)        6273  7992  7290  9532 11801  9249 11018 10660  3591  6805  9480  8071 11473 10956 16786  9367
   STANDARD DEVIATION      3808  2598  3470  3535  5175  3031  4971  1763  1765  2683  5422  2490  5212  2539 10053  3261

RATIO TO Z         PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A      0.74  0.75     -  0.67  0.65     -  0.65     -  0.61     -     -  0.75  0.62     -  0.70  0.73 D 0.69 0.05  8
M  EPA  DZUBAY   TF-M      0.57 *1.04 *0.82 *0.95 *0.84 *0.87  0.75     -  0.46  0.75  0.49 *0.79  0.73  0.74     -  0.61 M 0.75 0.17 22
N  EPA  DZUBAY   TF-P      0.49 *1.10 *0.96 *0.91     - *0.92 *0.80 *0.91  0.55 *1.13  0.40 *0.92 *0.81 *0.87 *0.81 *0.85 N 0.83 0.21 25
R  EPA  DZUBAY  MDS-S      0.73  0.67  0.75  0.60  0.54  0.63  0.62  0.63  0.58  0.76 *0.78  0.65  0.57  0.64  0.67  0.65 R 0.65 0.07 11
C  LBL  LOO     DICOT         -     -     -  1.25 *1.06  1.19 *1.03     - *0.93 *1.03  1.40  1.33  1.17 *1.02 *1.03  1.12 C 1.13 0.14 13
L  LBL  LOO     DICOT      1.63  1.41  1.31  1.31 *1.06  1.25  1.13     - *1.05  1.37  1.47  1.34  1.21  1.14 *1.05  1.23 L 1.27 0.17 13
S  LBL  LOO     DICOT      1.95  1.56  1.78     -  1.25  1.29  1.29     -  1.18  1.46     -     -     -  1.24 *1.09  1.26 S 1.40 0.27 19
G  UCD  CAHILL  SMDAY         -  0.71  0.58 *0.87  0.54  0.66  0.61 *0.98  0.74  0.60  0.57     -     -     -     -     - G 0.69 0.14 21
H  UCD  CAHILL  TTLF      *1.38 *1.03 *1.34 *0.92 *1.02 *0.93 *1.05 *1.02 *1.06 *1.00 *0.91 *1.17 *1.14 *0.89 *0.98 *0.94 H 1.05 0.15 14
I  UCD  CAHILL  SFU        0.50  0.73  0.45  0.63  0.70  0.65  0.62 *0.93  0.81  0.55  0.78  0.71  0.67 *0.97  0.37 *0.87 I 0.68 0.17 24
J  FSU  HUDSON  LS .2         -     -     -  1.33  1.72  1.34  1.85  1.29  2.31  1.30  1.38 *1.09  1.43  1.18  1.60  1.34 J 1.48 0.33 22
K  FSU  HUDSON  LS .4         -     -     -  1.56  1.62  1.28  1.61  1.25  1.70 *1.04  1.81  1.23  1.65  1.30  1.71  1.40 K 1.47 0.24 16

  MEAN(ALL SAMPLERS)       1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION      0.57  0.32  0.45  0.32  0.41  0.28  0.41  0.22  0.54  0.31  0.48  0.27  0.37  0.22  0.41  0.28   0.37

REGRESSION VS Z           INTERCEPT      ERROR       SLOPE       ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A       238.955    497.652       0.662       0.046   511.037      0.981
M  EPA  DZUBAY   TF-M     -1428.477   1602.926       0.912       0.166  1363.077      0.846
N  EPA  DZUBAY   TF-P       -76.524   1597.218       0.847       0.158  1718.718      0.830
R  EPA  DZUBAY  MDS-S       646.791    618.166       0.585       0.060   680.225      0.934
C  LBL  LOO     DICOT      1516.928   1278.370       0.981       0.118  1288.636      0.934
L  LBL  LOO     DICOT      3688.059   1123.230       0.872       0.108  1234.237      0.912
S  LBL  LOO     DICOT      4632.616   1993.842       0.898       0.189  2096.876      0.845
G  UCD  CAHILL  SMDAY      1246.805   1957.887       0.545       0.202  1502.191      0.690
H  UCD  CAHILL  TTLF       1206.161   1167.846       0.917       0.113  1285.090      0.908
I  UCD  CAHILL  SFU        2877.217   1661.787       0.378       0.161  1828.618      0.533
J  FSU  HUDSON  LS .2     -2307.378   2560.163       1.689       0.238  2592.593      0.906
K  FSU  HUDSON  LS .4     -3724.416   2092.543       1.853       0.195  2119.050      0.944
```

```
I                    INTERCOMPARISON STUDY OF SMALL SI  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16       AVG   SD

D  EPA  DZUBAY  MDS-A    1031  1271  1181   782   842     -   676  1622   782   756  1286  1001  1269     -  1320  1211 D
M  EPA  DZUBAY    TF-M   1359  1172  1405   893  1270   853  1397     -   539   616  1736   843  1215   720  2208   712 M
N  EPA  DZUBAY    TF-P   1879  1374  1309  1149  1749  1205  1517  1749   869   860  1603  1059  1758  1227  2088  1081 N
R  EPA  DZUBAY  MDS-S     748  1070   706   737   446   667   294  1539   496   448   917   828   699   743   733   723 R
C  LBL  LOO     DICOT       -     -     -   545   514   478   454     -   749   416   934   793   882   667   819   497 C
L  LBL  LOO     DICOT     925  1047   913   550   518   480   462     -   729   427   967   701   848   666   797   492 L
S  LBL  LOO     DICOT     839  1084   797     -   474   465   464     -   703   430   978     -     -   654   787   507 S
G  UCD  CAHILL  SMDAY    1750  1870  1250  1760  1490  2040  1240  3670  1220  1370  1270     -     -     -     -     - G
I  UCD  CAHILL  SFU      1133  1110  1833  1455  3258  1479  1543  3360 -2169  1846  2309 -2037  1954  1143  2365   617 I

Z MEAN(ALL SAMPLERS)     1208  1250  1174   984  1173   958   894  2388   917   797  1333  1037  1232   831  1390   730      1144  520
   STANDARD DEVIATION     419   274   367   438   921   573   519  1037   513   501   473   457   475   245   716   275

X MEAN(D,M,L,G,I)        1240  1294  1316  1088  1476  1213  1064  2884  1088  1003  1514  1146  1322   843  1673   758
   STANDARD DEVIATION     327   332   339   502  1065   688   470  1104   654   589   523   607   461   261   743   315

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16       AVG   SD CV

D  EPA  DZUBAY  MDS-A    0.85 •1.02 •1.01  0.80  0.72     -  0.76  0.68  0.85 •0.95 •0.96 •0.97 •1.03     - •0.95  1.66 D 0.94 0.24 25
M  EPA  DZUBAY    TF-M  •1.13 •0.94  1.20 •0.91 •1.08 •0.89  1.56     -  0.59  0.77  1.30  0.81 •0.99  0.87  1.59 •0.98 M 1.04 0.28 27
N  EPA  DZUBAY    TF-P   1.56 •1.10 •1.12  1.17  1.49  1.26  1.70  0.73 •0.95 •1.08  1.20 •1.02  1.43  1.48  1.50  1.48 N 1.27 0.26 21
R  EPA  DZUBAY  MDS-S    0.62  0.86  0.60  0.75  0.38  0.70  0.33  0.64  0.54  0.56  0.69  0.80  0.57 •0.89  0.53 •0.99 R 0.65 0.18 27
C  LBL  LOO     DICOT       -     -     -  0.55  0.44  0.50  0.51     -  0.82  0.52  0.70  0.76  0.72  0.80  0.59  0.68 C 0.63 0.13 21
L  LBL  LOO     DICOT    0.77  0.84  0.78  0.56  0.44  0.50  0.52     -  0.80  0.54  0.73  0.68  0.69  0.80  0.57  0.67 L 0.66 0.13 19
S  LBL  LOO     DICOT    0.69  0.87  0.68     -  0.40  0.49  0.52     -  0.77  0.54  0.73     -     -  0.79  0.57  0.69 S 0.65 0.14 22
G  UCD  CAHILL  SMDAY    1.45  1.50 •1.06  1.79 •1.27  2.13  1.39  1.54  1.33  1.72 •0.95     -     -     -     -     - G 1.47 0.33 23
I  UCD  CAHILL  SFU     •0.94 •0.89  1.56  1.48  2.78  1.54  1.73  1.41  2.36  2.32  1.73  1.96  1.59  1.38  1.70 •0.85 I 1.64 0.53 33

  MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00     1.00
   STANDARD DEVIATION    0.35  0.22  0.31  0.45  0.78  0.60  0.58  0.43  0.56  0.63  0.35  0.44  0.39  0.29  0.52  0.38     0.46

REGRESSION VS Z         INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A     460.916   163.924      0.520      0.132   191.161     0.750
M  EPA  DZUBAY    TF-M   -814.294   377.476      1.832      0.350   269.122     0.824
N  EPA  DZUBAY    TF-P    749.156   246.987      0.573      0.205   307.438     0.598
R  EPA  DZUBAY  MDS-S      60.839   142.480      0.591      0.118   177.353     0.800
C  LBL  LOO     DICOT      27.643   199.756      0.604      0.191   135.986     0.706
L  LBL  LOO     DICOT    -106.150   196.932      0.761      0.182   140.403     0.757
S  LBL  LOO     DICOT     -59.102   231.569      0.703      0.215   160.356     0.718
G  UCD  CAHILL  SMDAY      54.117   353.108      1.402      0.281   384.022     0.857
I  UCD  CAHILL  SFU       389.221   465.077      1.278      0.386   578.906     0.662
```

```
1                 INTERCOMPARISON STUDY OF LARGE SI  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16     AVG    SD

D  EPA  DZUBAY   MDS-A    5267   5190      -   5576   7628      -   7292      -   1661      -      -   5137   6158      -  10999   5847 D
M  EPA  DZUBAY    TF-M    2806   7798   6185   8190   9767   7790   7877      -   1320   5309   2800   5772   7320   7110      -   5183 M
N  EPA  DZUBAY    TF-P    1694   8056   7586   7581      -   7808   8372   7453   1347   8066   2130   6651   7857   7955  12128   7191 N
R  EPA  DZUBAY   MDS-S    4539   4656   6232   4946   6641   5515   7319   4828   1837   5556   6332   4641   6048   5975  10934   5554 R
C  LBL  LOO      DICOT       -      -      -  11371  13355  11207  12242      -   2777   7732  12064  10356  12920  10136  17250  10348 C
L  LBL  LOO      DICOT   10953  11095  11124  11971  13378  11798  13322      -   3480  10373  12613  10514  13428  11378  17677  11435 L
S  LBL  LOO      DICOT   13332  12286  15657      -  15964  12149  15478      -   4017  11135      -      -      -  12452  16335  11706 S
G  UCD  CAHILL   SMDAY       -   4264   4125   6570   5590   4393   6221   6225   1740   3408   3978      -      -      -      -      - G
I  UCD  CAHILL   SFU      2512   5142   2322   4513   5857   4932   7230   6046   1079   2498   4938   3930   5925   9057   4051   7759 I

Z MEAN(ALL SAMPLERS)      5872   7311   7604   7590   9773   8199   9484   6138   2162   6760   6408   6714   8522   9152  13053   8128    7679  3283
   STANDARD DEVIATION     4505   3057   4493   2813   3989   3169   3303   1074   1056   3112   4279   2681   3260   2328   5123   2677

X MEAN(D,M,L,G,I)         5385   6698   5939   7364   8444   7228   8388   6136   1856   5397   6082   6338   8208   9182  10909   7556
   STANDARD DEVIATION     3912   2791   3800   2910   3225   3392   2822    127    946   3518   4441   2887   3533   2137   6813   2807

RATIO TO Z       PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16     AVG    SD CV

D  EPA  DZUBAY   MDS-A   •0.90   0.71      -   0.74  •0.78      -  •0.77      -  •0.77      -      -  •0.77   0.72      -  •0.84   0.72 D  0.77  0.06  8
M  EPA  DZUBAY    TF-M    0.48  •1.07  •0.81  •1.08  •1.00  •0.95  •0.83      -   0.61  •0.79   0.44  •0.86  •0.86  •0.78      -   0.64 M  0.80  0.20 25
N  EPA  DZUBAY    TF-P    0.29  •1.10  •1.00  •1.00      -  •0.95  •0.88  •1.21   0.62  •1.19   0.33  •0.99  •0.92  •0.87  •0.93  •0.89 N  0.88  0.27 31
R  EPA  DZUBAY   MDS-S   •0.77   0.64  •0.82   0.65   0.68   0.67  •0.77  •0.79  •0.85  •0.82  •0.99   0.69   0.71   0.65  •0.84   0.68 R  0.75  0.10 13
C  LBL  LOO      DICOT       -      -      -   1.50   1.37   1.37   1.29      -   1.38   1.14   1.88   1.54   1.52  •1.11   1.32   1.27 C  1.39  0.21 15
L  LBL  LOO      DICOT    1.87   1.52   1.46   1.58   1.37   1.44   1.41      -   1.61   1.53   1.97   1.57   1.58   1.24   1.35   1.41 L  1.53  0.19 12
S  LBL  LOO      DICOT    2.27   1.68   2.06      -   1.63   1.48   1.63      -   1.86   1.65      -      -      -   1.36   1.40   1.44 S  1.68  0.28 17
G  UCD  CAHILL   SMDAY       -   0.58   0.54  •0.87   0.57   0.54   0.66  •1.01  •0.81   0.50   0.62      -      -      -      -      - G  0.67  0.17 25
I  UCD  CAHILL   SFU      0.43   0.70   0.31   0.59   0.60   0.60  •0.76  •0.99   0.50   0.37  •0.77   0.59   0.70  •0.99   0.31  •0.95 I  0.63  0.22 35

  MEAN(ALL SAMPLERS)      1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00    1.00
   STANDARD DEVIATION     0.77   0.42   0.59   0.37   0.41   0.39   0.35   0.18   0.49   0.46   0.67   0.40   0.38   0.25   0.39   0.33    0.43

REGRESSION VS Z          INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY   MDS-A    -372.738   474.498      0.820      0.057   484.373      0.981
M  EPA  DZUBAY    TF-M   -1847.693  1476.522      1.072      0.194  1329.379      0.848
N  EPA  DZUBAY    TF-P   -1005.701  1532.234      1.034      0.195  1685.445      0.827
R  EPA  DZUBAY   MDS-S      15.335   667.713      0.743      0.084   744.509      0.922
C  LBL  LOO      DICOT    1355.206  1468.358      1.206      0.176  1494.811      0.908
L  LBL  LOO      DICOT    2765.691  1062.408      1.140      0.131  1149.926      0.924
S  LBL  LOO      DICOT    3326.841  1813.536      1.211      0.217  1853.463      0.881
G  UCD  CAHILL   SMDAY    1065.548  1322.193      0.502      0.178  1133.320      0.706
I  UCD  CAHILL   SFU      1307.372  1723.441      0.463      0.216  1921.661      0.498
```

```
1                      INTERCOMPARISON STUDY OF TOTAL CA  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD

D EPA  DZUBAY  MDS-A     1870  1490     -  1790  2970     -  2570     -   460     -     -  1560  1990     -  2220  1610 D
M EPA  DZUBAY   TF-M     2050  2650  3150  3250  4520  3290  3570     -   590  2340  1950  2210  2860  2250     -  1940 M
N EPA  DZUBAY   TF-P     1550  2510  3170  2900     -  2980  3660  2440   585  2500  1510  2310  3000  2400  2900  2310 N
R EPA  DZUBAY  MDS-S     1510  1320  2220  1670  2780  1830  2470  1440   500  1640  2030  1460  1840  1560  2180  1440 R
C LBL  LOO     DICOT        -     -     -  3924  5293  3480  4129     -   784  2337  3976  3189  3992  2766  3558  2652 C
L LBL  LOO     DICOT     3724  3243  4080  4115  5325  3960  4595     -   937  3144  4164  3240  4134  3282  3712  3067 L
S LBL  LOO     DICOT     4682  3638  5690     -  6453  4133  5398     -  1028  2601     -     -     -  3523  3670  3052 S
G UCD  CAHILL  SMDAY        -  1570  1426  2307  2194  1848  2151  2350   474  1150  1346     -     -     -     -     - G
H UCD  CAHILL  TTLF      1851  1423  2795  2074  2987  1531  2339  1121   459  1630  1421  1714  2017  1330  2199  2143 H
I UCD  CAHILL  SFU       1303  1369  1499  1492  2587  1809  2708  1779   450  1002  1638  1425  2061  2082  1555  1914 I
J FSU  HUDSON  LS .2        -     -     -  2542  5459  2463  4592  1746  1654  2100  2900  2022  3165  2054  3298  1901 J
K FSU  HUDSON  LS .4        -     -     -  3304  5383  2433  4247  1710   856  1541  3042  1949  3270  2027  3386  1752 K

Z MEAN(ALL SAMPLERS)     2318  2135  3004  2675  4177  2705  3536  1798   731  2006  2398  2108  2833  2327  2868  2162     2486  885
  STANDARD DEVIATION     1215   893  1406   901  1491   919  1074   468   355   666  1056   656   838   695   771   552

X MEAN(D,M,L,G,I,K)      2237  2064  2539  2710  3830  2668  3307  1946   628  1835  2428  2077  2863  2410  2718  2057
  STANDARD DEVIATION     1041   835  1300  1011  1420   938   985   351   216   897  1163   721   893   589  1006   580

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D EPA  DZUBAY  MDS-A     0.81  0.70     -  0.67  0.71     -  0.73     -  0.63     -     -  0.74  0.70     -  0.77  0.75 D 0.72 0.05  7
M EPA  DZUBAY   TF-M     0.88  1.24 •1.05  1.22 •1.00  1.22 •1.01     -  0.81  1.17  0.81 •1.05 •1.01 •0.97     - •0.90 M 1.03 0.15 14
N EPA  DZUBAY   TF-P     0.67  1.18 •1.06 •1.09     - •1.10 •1.04  1.36  0.80  1.29  0.63 •1.10 •1.06 •1.03 •1.01 •1.07 N 1.03 0.20 19
R EPA  DZUBAY  MDS-S     0.65  0.62  0.74  0.63  0.67  0.68  0.70  0.80  0.68  0.82  0.85  0.69  0.65  0.67  0.76  0.67 R 0.70 0.07 10
C LBL  LOO     DICOT        -     -     -  1.47  1.27  1.29  1.17     - •1.07  1.17  1.66  1.51  1.41  1.19  1.24  1.23 C 1.31 0.17 13
L LBL  LOO     DICOT     1.61  1.52  1.36  1.54  1.28  1.46  1.30     -  1.28  1.57  1.74  1.54  1.46  1.41  1.29  1.42 L 1.45 0.14  9
S LBL  LOO     DICOT     2.02  1.70  1.89     -  1.55  1.53  1.53     -  1.41  1.30     -     -     -  1.51  1.28  1.41 S 1.56 0.23 15
G UCD  CAHILL  SMDAY        -  0.74  0.48  0.86  0.53  0.68  0.61  1.31  0.65  0.57  0.56     -     -     -     -     - G 0.70 0.24 35
H UCD  CAHILL  TTLF      0.80  0.67 •0.93  0.78  0.72  0.57  0.66  0.62  0.63  0.81  0.59  0.81  0.71  0.57  0.77 •0.99 H 0.73 0.12 17
I UCD  CAHILL  SFU       0.56  0.64  0.50  0.56  0.62  0.67  0.77 •0.99  0.62  0.50  0.68  0.68  0.73 •0.89  0.54 •0.89 I 0.68 0.15 21
J FSU  HUDSON  LS .2        -     -     - •0.95  1.31  0.91  1.30 •0.97  2.26 •1.05  1.21 •0.96  1.12  0.88  1.15  0.88 J 1.15 0.37 32
K FSU  HUDSON  LS .4        -     -     -  1.24  1.29  0.90  1.20 •0.95  1.17  0.77  1.27  0.92  1.15  0.87  1.18  0.81 K 1.06 0.19 18

 MEAN(ALL SAMPLERS)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
  STANDARD DEVIATION     0.52  0.42  0.47  0.34  0.36  0.34  0.30  0.26  0.49  0.33  0.44  0.31  0.30  0.30  0.27  0.26   0.36

REGRESSION VS Z         INTERCEPT      ERROR      SLOPE      ERROR  RMS.DEV.  COR.COEFF.
D EPA  DZUBAY  MDS-A        2.425    106.459      0.725      0.039   109.370      0.988
M EPA  DZUBAY   TF-M     -180.531    299.928      1.115      0.114   326.977      0.942
N EPA  DZUBAY   TF-P       78.375    444.531      1.001      0.181   434.339      0.837
R EPA  DZUBAY  MDS-S      101.866    144.134      0.660      0.056   164.764      0.954
C LBL  LOO     DICOT      149.787    389.230      1.254      0.146   408.867      0.939
L LBL  LOO     DICOT      628.987    294.462      1.192      0.112   321.287      0.948
S LBL  LOO     DICOT      -53.103    575.357      1.589      0.215   606.137      0.927
G UCD  CAHILL  SMDAY      652.352    455.204      0.409      0.170   487.932      0.648
H UCD  CAHILL  TTLF        15.989    272.546      0.724      0.105   311.556      0.879
I UCD  CAHILL  SFU        212.194    297.095      0.585      0.115   339.618      0.807
J FSU  HUDSON  LS .2     -308.817    467.321      1.235      0.179   517.651      0.901
K FSU  HUDSON  LS .4     -822.984    375.897      1.411      0.144   416.382      0.947
```

```
1                  INTERCOMPARISON STUDY OF SMALL CA  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD

D  EPA  DZUBAY  MDS-A      228   211   283   228   300     -   262   215   126   218   279   211   307     -   296   248 D
M  EPA  DZUBAY   TF-M      703   457   792   570   878   554   730     -   236   518   783   435   599   331   588   328 M
N  EPA  DZUBAY   TF-P      643   391   641   439   892   461   686   401   227   419   683   415   616   349   508   304 N
R  EPA  DZUBAY  MDS-S      162   143   214   167   220   195   207   177    98   162   178   172   170   124   188   123 R
C  LBL  LOO     DICOT      159     -     -   185   208   180   186     -   112   143   193   188   204   149   189   137 C
L  LBL  LOO     DICOT      169   205   246   197   202   197   200     -   107   146   193   166   203   155   149   146 L
S  LBL  LOO     DICOT      174   199   196     -   191   171   180     -    84   143   212     -     -   145   163   123 S
G  UCD  CAHILL  SMDAY      325   406   360   497   545   571   452   494   244   344   313     -     -     -     -     - G
I  UCD  CAHILL  SFU        288   241   347   322   560   266   248   417   187   280   332   254   379   227   365   166 I

Z MEAN(ALL SAMPLERS)       317   282   385   326   444   324   350   341   158   264   352   263   354   211   306   197     305   158
   STANDARD DEVIATION      211   118   216   157   288   174   219   137    65   137   224   115   187    94   168    84

X MEAN(D,M,L,G,I)          343   304   406   363   497   397   378   375   180   301   380   267   372   238   350   222
   STANDARD DEVIATION      210   119   221   165   263   193   219   144    62   142   232   118   168    88   183    83

RATIO TO Z       PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD CV

D  EPA  DZUBAY  MDS-A     0.72  0.75  0.74  0.70  0.68     -  0.75  0.63  0.80  0.83  0.79  0.80  0.87     - •0.97  1.26 D 0.81 0.16 19
M  EPA  DZUBAY   TF-M     2.22  1.62  2.06  1.75  1.98  1.71  2.09     -  1.50  1.96  2.23  1.65  1.69  1.57  1.92  1.67 M 1.84 0.24 13
N  EPA  DZUBAY   TF-P     2.03  1.39  1.67  1.35  2.01  1.42  1.96  1.18  1.44  1.59  1.94  1.58  1.74  1.65  1.66  1.54 N 1.63 0.25 15
R  EPA  DZUBAY  MDS-S     0.51  0.51  0.56  0.51  0.50  0.60  0.59  0.52  0.62  0.61  0.51  0.65  0.48  0.59  0.62  0.63 R 0.56 0.06 10
C  LBL  LOO     DICOT     0.50     -     -  0.57  0.47  0.56  0.53     -  0.71  0.54  0.55  0.72  0.58  0.71  0.62  0.70 C 0.60 0.09 14
L  LBL  LOO     DICOT     0.53  0.73  0.64  0.61  0.46  0.61  0.57     -  0.68  0.55  0.55  0.63  0.57  0.73  0.49  0.74 L 0.61 0.09 14
S  LBL  LOO     DICOT     0.55  0.71  0.51     -  0.43  0.53  0.51     -  0.53  0.54  0.60     -     -  0.69  0.53  0.63 S 0.56 0.08 14
G  UCD  CAHILL  SMDAY    •1.03  1.44 •0.94  1.53  1.23  1.76  1.29  1.45  1.55  1.31  0.89     -     -     -     -     - G 1.31 0.27 21
I  UCD  CAHILL  SFU      •0.91  0.86 •0.90 •0.99  1.26  0.82  0.71  1.22  1.18 •1.06 •0.94 •0.97 •1.07 •1.07  1.19  0.84 I 1.00 0.16 16

  MEAN(ALL SAMPLERS)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION     0.67  0.42  0.56  0.48  0.65  0.54  0.63  0.40  0.41  0.52  0.64  0.44  0.53  0.44  0.55  0.43    0.52

REGRESSION VS Z       INTERCEPT      ERROR       SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A    91.035     40.290       0.493      0.127    33.822      0.747
M  EPA  DZUBAY   TF-M  -151.457     66.442       2.377      0.214    60.192      0.951
N  EPA  DZUBAY   TF-P  -135.349     90.926       2.102      0.291    82.577      0.888
R  EPA  DZUBAY  MDS-S    40.567     15.936       0.421      0.051    14.472      0.911
C  LBL  LOO     DICOT    73.316     16.330       0.331      0.053    14.266      0.882
L  LBL  LOO     DICOT    65.877     22.915       0.374      0.074    20.760      0.815
S  LBL  LOO     DICOT    53.932     23.483       0.372      0.076    20.705      0.840
G  UCD  CAHILL  SMDAY   136.120    128.214       0.862      0.389    89.523      0.594
I  UCD  CAHILL  SFU     -30.842     61.087       1.103      0.195    55.478      0.833
```

```
1                 INTERCOMPARISON STUDY OF LARGE CA  :  NANOGRAMS/CUBIC METER; PERIODS 1-16  MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A    1644  1278     -  1563  2671     -  2306     -   331     -     -  1346  1682     -  1924  1358 D
M  EPA  DZUBAY   TF-M    1344  2197  2355  2677  3640  2735  2036     -   359  1821  1163  1776  2265  1922     -  1610 M
N  EPA  DZUBAY   TF-P     906  2119  2527  2459     -  2515  2974  2038   359  2058   828  1895  2386  2058  2396  2009 N
R  EPA  DZUBAY  MDS-S    1350  1175  2003  1503  2559  1634  2265  1262   398  1476  1854  1286  1671  1437  1990  1319 R
C  LBL  LOO     DICOT       -     -     -  3739  5085  3300  3943     -   672  2194  3783  3001  3788  2617  3369  2515 C
L  LBL  LOO     DICOT    3555  3038  3834  3918  5123  3763  4395     -   830  2998  3971  3674  3931  3127  3563  2921 L
S  LBL  LOO     DICOT    4508  3439  5494     -  6262  3962  5218     -   944  2458     -     -     -  3378  3507  2929 S
G  UCD  CAHILL  SMDAY       -  1164  1066  1810  1649  1277  1699  1856   330   806  1043     -     -     -     -     - G
I  UCD  CAHILL  SFU      1015  1128  1152  1170  2027  1543  2460  1362   263   722  1306  1171  1682  1855  1190  1748 I

Z MEAN(ALL SAMPLERS)     2046  1942  2633  2355  3627  2591  3122  1630   498  1817  1993  2021  2436  2342  2563  2051   2232  993
   STANDARD DEVIATION    1405   913  1569  1037  1683  1037  1154   376   250   788  1326   956   983   716   930   660

X MEAN(D,M,L,G,I)        1890  1761  2102  2228  3022  2330  2739  1609   423  1587  1871  1992  2390  2301  2226  1909
   STANDARD DEVIATION    1140   838  1296  1095  1396  1147  1012   349   230  1065  1404  1150  1063   716  1215   694

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A    0.80  0.66     -  0.66  0.74     -  0.74     -  0.66     -     -  0.67  0.68     -  0.75  0.66 D 0.70 0.05  7
M  EPA  DZUBAY   TF-M    0.66 •1.13 •0.89 •1.14 •1.00 •1.06 •0.91     -  0.72 •1.00  0.58 •0.88 •0.91  0.82     -  0.79 M 0.89 0.17 19
N  EPA  DZUBAY   TF-P    0.44 •1.09 •0.96 •1.04     - •0.97 •0.95  1.25  0.72 •1.13  0.42 •0.94 •0.96 •0.88 •0.94 •0.98 N 0.91 0.23 25
R  EPA  DZUBAY  MDS-S    0.66  0.61  0.76  0.64  0.71  0.63  0.73  0.77  0.80  0.81 •0.93  0.64  0.67  0.61  0.78  0.64 R 0.71 0.09 13
C  LBL  LOO     DICOT       -     -     -  1.59  1.40  1.27  1.26     -  1.35  1.21  1.90  1.49  1.52  1.12  1.31  1.23 C 1.39 0.21 15
L  LBL  LOO     DICOT    1.74  1.56  1.46  1.66  1.41  1.45  1.41     -  1.67  1.65  1.99  1.82  1.58  1.34  1.39  1.42 L 1.57 0.19 12
S  LBL  LOO     DICOT    2.20  1.77  2.09     -  1.73  1.53  1.67     -  1.89  1.35     -     -     -  1.44  1.37  1.43 S 1.68 0.29 17
G  UCD  CAHILL  SMDAY       -  0.60  0.41  0.77  0.46  0.49  0.54 •1.14  0.66  0.44  0.52     -     -     -     -     - G 0.60 0.22 36
I  UCD  CAHILL  SFU      0.50  0.58  0.44  0.50  0.56  0.60  0.79 •0.84  0.53  0.40  0.66  0.58  0.68  0.79  0.46 •0.85 I 0.61 0.15 24

  MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION    0.69  0.47  0.60  0.44  0.46  0.40  0.37  0.23  0.50  0.43  0.67  0.47  0.40  0.31  0.36  0.32   0.45

REGRESSION VS Z         INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A    -107.809   107.871      0.756      0.045   111.030      0.986
M  EPA  DZUBAY   TF-M    -313.112   319.013      1.049      0.136   346.803      0.913
N  EPA  DZUBAY   TF-P     -97.891   451.644      0.966      0.204   453.533      0.796
R  EPA  DZUBAY  MDS-S      52.768   167.134      0.681      0.072   190.208      0.930
C  LBL  LOO     DICOT     141.423   455.011      1.322      0.189   477.125      0.911
L  LBL  LOO     DICOT     652.945   343.923      1.257      0.145   374.139      0.923
S  LBL  LOO     DICOT     -61.516   641.340      1.695      0.265   672.880      0.905
G  UCD  CAHILL  SMDAY     460.189   364.035      0.365      0.154   398.740      0.642
I  UCD  CAHILL  SFU        18.209   294.487      0.602      0.126   335.143      0.786
```

```
I                   INTERCOMPARISON STUDY OF TOTAL TI  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A     192   214     -   222   273     -   198     -    24     -     -   151   265     -   379   252 D
M  EPA  DZUBAY   TF-M     162   294   300   338   442   273   289     -    25   197   186   255   347   286     -   231 M
N  EPA  DZUBAY   TF-P      95   295   242   280     -   297   224   267    73   268    90   190   347   258   411   256 N
R  EPA  DZUBAY  MDS-S     172   186   254   192   213   171   212   166    73   192   241   155   222   220   388   193 R
C  LBL  LOO     DICOT       -     -     -   356   393   308   299     -    95   220   405   330   404   322   449   297 C
L  LBL  LOO     DICOT     319   376   381   386   379   333   352     -   102   309   441   322   431   381   482   339 L
S  LBL  LOO     DICOT     382   406   501     -   456   346   397     -   117   322     -     -     -   464   480   333 S
G  UCD  CAHILL  SMDAY       -   150   120   188   123   121   135   160    69    95   132     -     -     -     -     - G
H  UCD  CAHILL  TTLF      149   156   214   182   213   148   145   128    74   121   153   170   214   163   251   120 H
I  UCD  CAHILL  SFU       153   135   148   121   122   182   303   187     -   189   160   240   191   181   197   128 I
J  FSU  HUDSON  LS .2       -     -     -   190   284   174   275   139   135   156   278   156   281   242   471   213 J
K  FSU  HUDSON  LS .4       -     -     -   333   350   271   331   217   183   219   350   218   369   325   505   245 K

Z MEAN(ALL SAMPLERS)      203   246   270   253   295   239   263   181    88   208   244   219   307   284   401   237     246   90
   STANDARD DEVIATION      97   101   124    88   119    81    81    48    46    71   121    67    84    92   103    72

X MEAN(D,M,L,G,I,K)       207   234   237   265   282   236   268   188    81   202   254   237   321   293   391   239
   STANDARD DEVIATION      77   101   124   103   135    84    84    29    66    76   135    62    94    84   140    75

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A •0.95  0.87     -  0.88 •0.92     -  0.75     -  0.27     -     -  0.69  0.86     - •0.94 •1.06 D 0.82 0.22 27
M  EPA  DZUBAY   TF-M  0.80  1.20 •1.11  1.33  1.50 •1.14 •1.10     -  0.28 •0.95  0.76 •1.17 •1.13 •1.01     - •0.98 M 1.03 0.29 28
N  EPA  DZUBAY   TF-P  0.47 •1.20 •0.90 •1.11     -  1.25 •0.85  1.48 •0.83  1.29  0.37 •0.87 •1.13 •0.91 •1.02 •1.08 N 0.98 0.29 30
R  EPA  DZUBAY  MDS-S  0.85  0.76 •0.94  0.76  0.72  0.72  0.81 •0.92  0.83 •0.92 •0.99  0.71  0.72  0.77 •0.97  0.81 R 0.82 0.10 12
C  LBL  LOO     DICOT     -     -     -  1.40  1.33  1.29  1.14     - •1.08 •1.06  1.66  1.51  1.32  1.13  1.12  1.25 C 1.27 0.19 15
L  LBL  LOO     DICOT  1.57  1.53  1.41  1.52  1.28  1.40  1.34     -  1.16  1.49  1.81  1.47  1.40  1.34  1.20  1.43 L 1.42 0.16 11
S  LBL  LOO     DICOT  1.88  1.65  1.86     -  1.54  1.45  1.51     -  1.33  1.55     -     -     -  1.63  1.20  1.41 S 1.55 0.21 13
G  UCD  CAHILL  SMDAY     -  0.61  0.44  0.74  0.42  0.51  0.51 •0.89  0.78  0.46  0.54     -     -     -     -     - G 0.59 0.16 27
H  UCD  CAHILL  TTLF   0.73  0.64  0.79  0.72  0.72  0.62  0.55  0.71  0.84  0.58  0.63  0.78  0.70  0.57  0.63  0.51 H 0.67 0.09 14
I  UCD  CAHILL  SFU    0.75  0.55  0.55  0.48  0.41  0.76 •1.15 •1.04     - •0.91  0.66 •1.10  0.62  0.64  0.49  0.54 I 0.71 0.24 33
J  FSU  HUDSON  LS .2     -     -     -  0.75 •0.96  0.73 •1.04  0.77  1.53  0.75  1.14  0.71  0.92  0.85  1.17 •0.90 J 0.94 0.24 25
K  FSU  HUDSON  LS .4     -     -     -  1.31 •1.19  1.14  1.26  1.20  2.08 •1.05  1.44 •1.00  1.20  1.14  1.26 •1.03 K 1.25 0.27 22

  MEAN(ALL SAMPLERS)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION  0.48  0.41  0.46  0.35  0.40  0.34  0.31  0.27  0.52  0.34  0.50  0.31  0.27  0.33  0.26  0.30    0.37

REGRESSION VS Z        INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A    -58.800    29.270      1.097      0.111    26.830      0.961
M  EPA  DZUBAY   TF-M   -137.890    57.785      1.655      0.236    45.387      0.897
N  EPA  DZUBAY   TF-P     -8.179    67.119      1.020      0.267    67.254      0.727
R  EPA  DZUBAY  MDS-S    -15.172    26.903      0.887      0.106    27.179      0.913
C  LBL  LOO     DICOT     31.590    50.197      1.151      0.191    46.297      0.885
L  LBL  LOO     DICOT     63.959    39.476      1.164      0.153    37.851      0.904
S  LBL  LOO     DICOT     78.020    61.196      1.223      0.236    56.517      0.865
G  UCD  CAHILL  SMDAY     64.015    40.440      0.285      0.172    30.276      0.507
H  UCD  CAHILL  TTLF      16.583    20.957      0.593      0.082    21.172      0.887
I  UCD  CAHILL  SFU      167.193    66.099      0.034      0.253    50.148      0.037
J  FSU  HUDSON  LS .2    -43.787    47.130      1.107      0.183    46.183      0.877
K  FSU  HUDSON  LS .4     28.463    37.725      1.101      0.147    36.966      0.915
```

```
1                 INTERCOMPARISON STUDY OF SMALL TI  :  NANOGRAMS/CUBIC METER; PERIODS 1-16. MAY 11-18 1977.

RESULTS          PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD

D  EPA  DZUBAY   MDS-A      50    53    80    24    56     -     5    11     0    36    48    33    65     -    51    82 D
M  EPA  DZUBAY    TF-M      72    57    76    76    92    70    90     -     0    52    91   -41    86    22    85    72 M
N  EPA  DZUBAY    TF-P      58     0    22     0    29    40     0    32     0     9     0     0    53    48    72    51 N
R  EPA  DZUBAY   MDS-S      29    14    45    36    31    21    28    40    10    37    26    32    24    37    54    36 R
C  LBL  LOO      DICOT      28     -     -    35    29    27    25     -    17    25    33    34    33    38    28    20 C
L  LBL  LOO      DICOT      29    45    51    38    29    29    31     -    13    18    36    32    41    41    32    29 L
S  LBL  LOO      DICOT      27    46    43     -    25    26    27     -    13    22     -     -     -    41    33    23 S
G  UCD  CAHILL   SMDAY      26    60    28    51    23    29    33    40    30    21   232     -     -     -     -     - G
I  UCD  CAHILL   SFU        40    40    93    91    35    52   160  -130     -   105    45  -141    53    40   112    50 I

Z MEAN(ALL SAMPLERS)        40    39    55    44    39    37    44    51    10    36    64    45    51    38    58    45      44    29
   STANDARD DEVIATION       17    21    26    29    22    17    50    46    10    29    73    44    21     8    30    23

X MEAN(D,M,L,G,I)           43    51    66    56    47    45    64    60    11    46    90    62    61    34    70    58
   STANDARD DEVIATION       19     8    26    27    28    20    62    62    14    35    82    53    19    11    36    24

RATIO TO Z       PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD CV

D  EPA  DZUBAY   MDS-A    1.25  1.35  1.46  0.55  1.44     -  0.11  0.22  0.   •1.00  0.75  0.74  1.28     - •0.87  1.81 D 0.92  0.55 60
M  EPA  DZUBAY    TF-M    1.81 •1.45 •1.39  1.73  2.37  1.91  2.03     - •0.   •1.44  1.43 •0.92  1.70 •0.58  1.46  1.59 M 1.45  0.59 40
N  EPA  DZUBAY    TF-P   •1.45  0.    0.40  0.   •0.75 •1.09  0.   •0.63 •0.    0.25  0.    0.   •1.05 •1.26 •1.23 •1.12 N 0.58  0.55 96
R  EPA  DZUBAY   MDS-S    0.73  0.36 •0.82 •0.82 •0.80  0.57  0.63  0.79 •0.96 •1.02  0.41  0.72  0.47 •0.97 •0.93  0.79 R 0.74  0.20 27
C  LBL  LOO      DICOT    0.70     -     -  0.80  0.75  0.74  0.56     -  1.64  0.69  0.52  0.76  0.65 •1.00  0.48  0.44 C 0.75  0.31 41
L  LBL  LOO      DICOT    0.73 •1.14 •0.93 •0.87  0.75  0.79  0.70     - •1.25  0.50  0.56  0.72  0.81 •1.08  0.55  0.64 L 0.80  0.22 28
S  LBL  LOO      DICOT    0.68  1.17  0.79     -  0.65  0.71  0.61     - •1.25  0.61     -     -     - •1.08  0.57  0.51 S 0.78  0.26 33
G  UCD  CAHILL   SMDAY    0.65  1.52  0.51  1.16  0.59  0.79  0.74  0.79  2.89  0.58  3.63     -     -     -     -     - G 1.26  1.04 83
I  UCD  CAHILL   SFU     •1.00 •1.02  1.70  2.07 •0.90  1.42  3.61  2.57     -  2.91  0.70  3.15 •1.05 •1.05  1.92 •1.10 I 1.74  0.93 53

  MEAN(ALL SAMPLERS)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION     0.42  0.54  0.47  0.66  0.57  0.45  1.13  0.91  1.01  0.80  1.14  0.99  0.41  0.21  0.51  0.50    0.67

REGRESSION VS Z          INTERCEPT       ERROR       SLOPE      ERROR  RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY   MDS-A       0.618      24.043       0.942      0.523    23.752       0.462
M  EPA  DZUBAY    TF-M      -5.169      18.069       1.642      0.405    18.538       0.747
N  EPA  DZUBAY    TF-P       3.963      24.666       0.504      0.548    25.403       0.239
R  EPA  DZUBAY   MDS-S       7.268       8.958       0.551      0.199     9.226       0.595
C  LBL  LOO      DICOT      18.253       5.398       0.244      0.122     5.387       0.516
L  LBL  LOO      DICOT      11.608       7.694       0.496      0.172     7.894       0.623
S  LBL  LOO      DICOT      10.458       9.300       0.477      0.222     8.633       0.582
G  UCD  CAHILL   SMDAY     -54.261      54.394       2.550      1.247    53.002       0.563
I  UCD  CAHILL   SFU        35.849      63.916       0.947      1.377    43.086       0.187
```

1

INTERCOMPARISON STUDY OF LARGE TI : NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD
D	EPA	DZUBAY	MDS-A	142	161	-	198	217	-	193	-	24	-	-	118	200	-	328	170	D		
M	EPA	DZUBAY	TF-M	90	237	224	262	350	203	199	-	25	145	95	214	261	264	-	159	M		
N	EPA	DZUBAY	TF-P	37	295	220	283	-	257	224	235	73	259	89	192	294	210	339	205	N		
R	EPA	DZUBAY	MDS-S	143	172	209	156	182	150	184	126	63	155	215	123	198	183	334	157	R		
C	LBL	LOO	DICOT	-	-	-	321	364	281	274	-	78	195	372	296	371	284	421	277	C		
L	LBL	LOO	DICOT	290	331	330	349	350	304	321	-	89	291	405	290	390	340	450	310	L		
S	LBL	LOO	DICOT	355	360	458	-	431	320	370	-	104	300	-	-	-	363	447	310	S		
G	UCD	CAHILL	SMDAY	-	90	92	137	100	92	102	120	39	74	81	-	-	-	-	-	G		
I	UCD	CAHILL	SFU	113	95	55	30	87	130	143	57	-	83	115	99	138	141	-85	78	I		
Z	MEAN(ALL SAMPLERS)			167	218	227	217	260	217	223	135	62	188	196	190	265	255	343	208		211	100
	STANDARD DEVIATION			114	104	137	107	131	86	85	74	30	89	139	81	94	82	126	84			
X	MEAN(D,M,L,G,I)			159	183	175	195	221	182	192	89	44	148	174	180	247	248	288	179			
	STANDARD DEVIATION			90	102	126	121	128	93	82	45	31	100	155	89	108	100	186	96			

RATIO TO Z			PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD	CV
D	EPA	DZUBAY	MDS-A	0.85	0.74	-	•0.91	0.83	-	0.86	-	0.39	-	-	0.62	0.76	-	•0.96	0.82	D	0.77	0.17	21
M	EPA	DZUBAY	TF-M	0.54	•1.09	•0.99	1.21	1.35	•0.94	•0.89	-	0.40	0.77	0.49	•1.12	•0.99	•1.04	-	0.76	M	0.90	0.28	31
N	EPA	DZUBAY	TF-P	0.22	1.36	•0.97	1.30	-	•1.18	•1.00	1.75	•1.18	1.38	0.45	•1.01	•1.11	0.82	•0.99	•0.98	N	1.05	0.37	35
R	EPA	DZUBAY	MDS-S	0.86	0.79	•0.92	0.72	0.70	0.69	0.82	•0.94	•1.02	0.83	•1.10	0.65	0.75	0.72	•0.97	0.75	R	0.83	0.13	16
C	LBL	LOO	DICOT	-	-	-	1.48	1.40	1.29	1.23	-	1.26	•1.04	1.90	1.56	1.40	1.11	1.23	1.33	C	1.35	0.23	17
L	LBL	LOO	DICOT	1.74	1.52	1.46	1.61	1.35	1.40	1.44	-	1.44	1.55	2.07	1.52	1.47	1.33	1.31	1.49	L	1.51	0.19	12
S	LBL	LOO	DICOT	2.12	1.65	2.02	-	1.66	1.47	1.66	-	1.68	1.60	-	-	-	1.42	1.30	1.49	S	1.64	0.24	15
G	UCD	CAHILL	SMDAY	-	0.41	0.41	0.63	0.38	0.42	0.46	•0.89	0.63	0.39	0.41	-	-	-	-	-	G	0.50	0.17	33
I	UCD	CAHILL	SFU	0.68	0.44	0.24	0.14	0.33	0.60	0.64	0.42	-	0.44	0.59	0.52	0.52	0.55	0.25	0.37	I	0.45	0.16	35
	MEAN(ALL SAMPLERS)			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		
	STANDARD DEVIATION			0.68	0.48	0.60	0.49	0.50	0.40	0.38	0.55	0.48	0.47	0.71	0.43	0.35	0.32	0.37	0.40		0.48		

REGRESSION VS Z				INTERCEPT	ERROR	SLOPE	ERROR	RMS.DEV.	COR.COEFF.
D	EPA	DZUBAY	MDS-A	-47.643	20.895	1.034	0.092	20.132	0.970
M	EPA	DZUBAY	TF-M	-105.557	53.451	1.454	0.252	45.637	0.857
N	EPA	DZUBAY	TF-P	19.409	61.959	0.939	0.287	66.626	0.672
R	EPA	DZUBAY	MDS-S	-0.335	26.108	0.817	0.119	28.348	0.878
C	LBL	LOO	DICOT	32.793	49.865	1.196	0.219	47.845	0.865
L	LBL	LOO	DICOT	68.482	36.882	1.178	0.165	37.028	0.893
S	LBL	LOO	DICOT	84.743	53.845	1.218	0.239	51.813	0.862
G	UCD	CAHILL	SMDAY	44.198	27.828	0.250	0.138	23.503	0.539
I	UCD	CAHILL	SFU	68.265	42.975	0.128	0.191	34.551	0.184

```
1
                         INTERCOMPARISON STUDY OF TOTAL FE  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.
 RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD
 D  EPA  DZUBAY  MDS-A    1380  1240     -  1410  1640     -  1520     -   490     -     -  1270  1530     -  2020  1390 D
 M  EPA  DZUBAY   TF-M    1460  2060  2090  2190  2630  2290  2050     -   700  1690  1310  1700  2170  1850     -  1460 M
 N  EPA  DZUBAY   TF-P    1150  2030  2170  1980     -  2160  2170 -2010   620  2090  1050  1910  2340  2040  2550  1790 N
 R  EPA  DZUBAY  MDS-S    1200  1110  1610  1210  1520  1410  1500  1290   570  1300  1510  1080  1420  1400  1980  1250 R
 C  LBL  LOO     DICOT       -     -     -  2400  2532  2335  2155     -   770  1635  2480  2206  2685  2001  2637  1913 C
 L  LBL  LOO     DICOT    2360  2181  2469  2533  2536  2517  2426     -   891  2163  2617  2211  2800  2338  2755  2172 L
 S  LBL  LOO     DICOT    2908  2456  3356     -  3053  2604  2792     -  1024  2254     -     -     -  2500  2855  2178 S
 G  UCD  CAHILL  SMDAY       -  1091  1111  1519  1375  1225  1097  1549   525   901  1083     -     -     -     -     - G
 H  UCD  CAHILL  TTLF     1004  1159  1686  1515  1756  1389  1360  1316   490  1189  1003  1467  1881  1402  1758  1271 H
 I  UCD  CAHILL  SFU      1026  1024   950  1015  1275  1112  1205  1392   497   735  1073   943  1484  1539  1026  1321 I
 J  FSU  HUDSON  LS .2       -     -     -  1613  2699  1796  2501  1379  1237  1466  2089  1469  2401  1799  3059  1750 J
 K  FSU  HUDSON  LS .4       -     -     -  2244  2823  1943  2513  1557   897  1236  2483  1715  2814  1982  3141  1744 K
 Z MEAN(ALL SAMPLERS)     1561  1595  1930  1784  2167  1889  1941  1499   726  1514  1670  1597  2153  1885  2378  1658   1747  526
    STANDARD DEVIATION     696   572   775   509   653   536   578   248   243   506   673   435   546   369   668   343
 X MEAN(D,M,L,G,I,K)      1557  1519  1655  1819  2047  1817  1802  1499   667  1345  1713  1568  2160  1927  2236  1617
    STANDARD DEVIATION     568   556   740   589   692   628   615    93   192   585   771   483   650   331   931   349
 RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD CV
 D  EPA  DZUBAY  MDS-A    0.83  0.78     -  0.79  0.76     -  0.78     -  0.68     -     -  0.80  0.71     -  0.85  0.84 D 0.79 0.06  8
 M  EPA  DZUBAY   TF-M    0.94  1.29  1.08  1.23  1.21  1.21 •1.06     - •0.96  1.12  0.78  1.06 •1.01 •0.90     -  0.88 M 1.06 0.15 14
 N  EPA  DZUBAY   TF-P    0.74  1.27  1.12  1.11     -  1.14  1.12  1.34  0.85  1.38  0.63  1.20  1.09  1.08  1.07  1.08 N 1.08 0.21 19
 R  EPA  DZUBAY  MDS-S    0.77  0.70  0.83  0.68  0.70  0.75  0.77  0.86  0.79  0.86  0.90  0.68  0.66  0.74  0.83  0.75 R 0.77 0.07 10
 C  LBL  LOO     DICOT       -     -     -  1.35  1.17  1.24 •1.11     - •1.06 •1.08  1.49  1.38  1.25 •1.06 •1.11  1.15 C 1.20 0.14 12
 L  LBL  LOO     DICOT    1.51  1.37  1.28  1.42  1.17  1.33  1.25     -  1.23  1.43  1.57  1.38  1.30  1.24  1.16  1.31 L 1.33 0.12  9
 S  LBL  LOO     DICOT    1.86  1.54  1.74     -  1.41  1.38  1.44     -  1.41  1.49     -     -     -  1.33  1.20  1.31 S 1.46 0.19 13
 G  UCD  CAHILL  SMDAY       -  0.68  0.58  0.85  0.63  0.65  0.57 •1.03  0.72  0.60  0.65     -     -     -     -     - G 0.70 0.15 21
 H  UCD  CAHILL  TTLF     0.64  0.73 •0.87  0.85  0.81  0.74  0.70 •0.88  0.68  0.79  0.60 •0.92 •0.87  0.74  0.74  0.77 H 0.77 0.09 12
 I  UCD  CAHILL  SFU      0.66  0.64  0.49  0.57  0.59  0.59  0.62 •0.93  0.69  0.49  0.64  0.59  0.69  0.82  0.43  0.80 I 0.64 0.13 20
 J  FSU  HUDSON  LS .2       -     -     -  0.90  1.25 •0.95  1.29 •0.92  1.70 •0.97  1.25 •0.92  1.12 •0.95  1.29 •1.06 J 1.12 0.23 21
 K  FSU  HUDSON  LS .4       -     -     -  1.26  1.30 •1.03  1.30 •1.04  1.24  0.82  1.49 •1.07  1.31 •1.05  1.32 •1.05 K 1.17 0.18 15
   MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
    STANDARD DEVIATION    0.45  0.36  0.40  0.29  0.30  0.28  0.30  0.17  0.33  0.33  0.40  0.27  0.25  0.20  0.28  0.21   0.30
 REGRESSION VS Z          INTERCEPT       ERROR       SLOPE       ERROR   RMS.DEV.  COR.COEFF.
 D  EPA  DZUBAY  MDS-A      -34.674     138.113       0.811       0.076    105.438       0.966
 M  EPA  DZUBAY   TF-M     -230.956     348.022       1.200       0.199    253.706       0.868
 N  EPA  DZUBAY   TF-P      -73.757     415.166       1.131       0.237    327.271       0.799
 R  EPA  DZUBAY  MDS-S       82.171     168.876       0.717       0.095    137.293       0.897
 C  LBL  LOO     DICOT      107.011     317.160       1.145       0.174    241.887       0.902
 L  LBL  LOO     DICOT      462.945     248.390       1.060       0.138    196.851       0.905
 S  LBL  LOO     DICOT      453.633     465.109       1.195       0.259    351.838       0.838
 G  UCD  CAHILL  SMDAY      298.432     345.368       0.508       0.202    238.547       0.665
 H  UCD  CAHILL  TTLF      -108.297     194.166       0.837       0.109    157.854       0.899
 I  UCD  CAHILL  SFU        358.638     275.969       0.425       0.155    224.359       0.592
 J  FSU  HUDSON  LS .2      -78.979     412.605       1.150       0.229    324.642       0.834
 K  FSU  HUDSON  LS .4     -473.240     383.619       1.454       0.213    301.835       0.900
```

```
1                    INTERCOMPARISON STUDY OF SMALL FE  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA DZUBAY    MDS-A   366   294   454   306   315     -   289   354   175   238   310   282   361     -   356   350 D
M  EPA DZUBAY     TF-M   810   511   866   606   740   652   722     -   372   486   740   465   625   481   787   474 M
N  EPA DZUBAY     TF-P   751   441   712   521   733   532   698   537   321   416   621   431   674   459   704   415 N
R  EPA DZUBAY    MDS-S   304   235   385   253   264   279   230   314   154   203   230   232   219   217   258   188 R
C  LBL LOO       DICOT   293     -     -   238   235   215   210     -   153   148   226   223   242   191   223   171 C
L  LBL LOO       DICOT   300   217   382   241   239   232   213     -   153   154   225   191   237   194   207   177 L
S  LBL LOO       DICOT   308   223   362     -   250   217   217     -   155   161   238     -     -   198   211   165 S
G  UCD CAHILL    SMDAY   373   369   431   477   413   489   264   631   197   331   386     -     -     -     -     - G
I  UCD CAHILL    SFU     417   233   437   313   423   303   360   487   216   231   355   291   368   254   374   211 I

Z MEAN(ALL SAMPLERS)     436   315   504   369   401   365   356   465   211   263   370   302   389   285   390   269     356  158
   STANDARD DEVIATION    200   113   184   144   203   169   206   131    81   122   188   106   188   128   229   125

X MEAN(D,M,L,G,I)        453   325   514   389   426   419   370   491   223   288   403   307   398   310   431   303
   STANDARD DEVIATION    204   120   199   150   191   189   204   139    87   127   198   114   163   151   249   136

RATIO TO Z      PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA DZUBAY    MDS-A  0.84  0.93  0.90  0.83  0.79     -  0.81  0.76  0.83  0.90  0.84  0.93  0.93     -  0.91  1.30 D 0.89 0.13 15
M  EPA DZUBAY     TF-M  1.86  1.62  1.72  1.64  1.84  1.79  2.03     -  1.77  1.85  2.00  1.54  1.61  1.69  2.02  1.76 M 1.78 0.15  9
N  EPA DZUBAY     TF-P  1.72  1.40  1.41  1.41  1.83  1.46  1.96  1.16  1.52  1.58  1.68  1.43  1.73  1.61  1.81  1.54 N 1.58 0.20 13
R  EPA DZUBAY    MDS-S  0.70  0.75  0.76  0.69  0.66  0.77  0.65  0.68  0.73  0.77  0.62  0.77  0.56  0.76  0.66  0.70 R 0.70 0.06  9
C  LBL LOO       DICOT  0.67     -     -  0.64  0.59  0.59  0.59     -  0.73  0.56  0.61  0.74  0.62  0.67  0.57  0.64 C 0.63 0.06  9
L  LBL LOO       DICOT  0.69  0.69  0.76  0.65  0.60  0.64  0.60     -  0.73  0.59  0.61  0.63  0.61  0.68  0.53  0.66 L 0.64 0.06  9
S  LBL LOO       DICOT  0.71  0.71  0.72     -  0.62  0.60  0.61     -  0.74  0.61  0.64     -     -  0.70  0.54  0.61 S 0.65 0.06  9
G  UCD CAHILL    SMDAY  0.86  1.17  0.86  1.29 •1.03  1.34  0.74  1.36 •0.94  1.26 •1.04     -     -     -     -     - G 1.08 0.22 20
I  UCD CAHILL    SFU   •0.96  0.74  0.87  0.85 •1.05  0.83 •1.01 •1.05 •1.03 •0.88 •0.96 •0.96 •0.95 •0.89 •0.96  0.79 I 0.92 0.09 10

  MEAN(ALL SAMPLERS)    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION   0.46  0.36  0.36  0.39  0.51  0.46  0.58  0.28  0.39  0.46  0.51  0.35  0.48  0.45  0.59  0.46   0.44

REGRESSION VS Z         INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA DZUBAY    MDS-A     73.931    46.597      0.678      0.126    37.154      0.840
M  EPA DZUBAY     TF-M    -33.050    71.147      1.882      0.200    56.204      0.934
N  EPA DZUBAY     TF-P     50.263   101.525      1.434      0.279    84.549      0.808
R  EPA DZUBAY    MDS-S     20.101    27.507      0.640      0.076    22.908      0.915
C  LBL LOO       DICOT     28.560    25.714      0.544      0.075    17.112      0.910
L  LBL LOO       DICOT    -19.942    29.987      0.701      0.084    23.689      0.917
S  LBL LOO       DICOT    -11.449    29.936      0.683      0.084    22.995      0.932
G  UCD CAHILL    SMDAY     51.944   125.318      0.935      0.332    89.171      0.684
I  UCD CAHILL    SFU      -35.920    39.383      1.028      0.108    32.798      0.930
```

```
1                    INTERCOMPARISON STUDY OF LARGE FE  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD

D  EPA  DZUBAY  MDS-A    1012   948     -  1105  1323     -  1235     -   314     -     -   984  1170     -  1661  1044 D
M  EPA  DZUBAY   TF-M     653  1549  1228  1588  1891  1640  1334     -   319  1196   574  1237  1549  1374     -   985 M
N  EPA  DZUBAY   TF-P     395  1589  1454  1464     -  1623  1469 -1474   299  1669   432  1478  1663  1576  1849  1376 N
R  EPA  DZUBAY  MDS-S     891   877  1225   960  1256  1134  1269   974   413  1095  1281   849  1201  1182  1719  1059 R
C  LBL  LOO     DICOT       -     -     -  2162  2297  2120  1945     -   317  1487  2254  1983  2443  1810  2414  1742 C
L  LBL  LOO     DICOT    2060  1964  2087  2292  2297  2285  2213     -   738  2009  2392  2020  2563  2144  2548  1995 L
S  LBL  LOO     DICOT    2600  2233  2994     -  2803  2387  2575     -   869  2093     -     -     -  2302  2644  2013 S
G  UCD  CAHILL  SMDAY       -   722   680  1042   956   736   833   918   328   570   697     -     -     -     -     - G
I  UCD  CAHILL  SFU       609   791   513   702   853   809   845   905   281   504   718   652  1116  1285   652  1110 I

Z MEAN(ALL SAMPLERS)     1174  1334  1454  1414  1710  1592  1524  1068   464  1328  1193  1315  1672  1668  1927  1416    1331  601
   STANDARD DEVIATION     829   579   852   574   715   649   600   272   220   599   817   539   604   433   693   438

X MEAN(D,M,L,G,I)        1084  1195  1127  1346  1464  1368  1292   912   396  1070  1095  1223  1600  1601  1620  1284
   STANDARD DEVIATION     676   540   709   616   618   736   562     9   192   700   867   583   671   472   949   477

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD CV

D  EPA  DZUBAY  MDS-A    0.86  0.71     -  0.78  0.77     -  0.81     -  0.68     -     -  0.75  0.70     -  0.86  0.74 D 0.77 0.06  8
M  EPA  DZUBAY   TF-M    0.56  1.16  0.84  1.12  1.11 •1.03  0.88     -  0.69  0.90  0.48 •0.94  0.93  0.82     -  0.70 M 0.87 0.21 24
N  EPA  DZUBAY   TF-P    0.34  1.19 •1.00 •1.04     - •1.02 •0.96  1.38  0.64  1.26  0.36  1.12 •0.99 •0.95 •0.96 •0.97 N 0.95 0.29 31
R  EPA  DZUBAY  MDS-S    0.76  0.66  0.84  0.68  0.74  0.71  0.83  0.91  0.89  0.82 •1.07  0.65  0.72  0.71  0.89  0.75 R 0.79 0.11 14
C  LBL  LOO     DICOT       -     -     -  1.53  1.34  1.33  1.28     -  1.33  1.12  1.89  1.51  1.46 •1.09  1.25  1.23 C 1.36 0.22 16
L  LBL  LOO     DICOT    1.75  1.47  1.44  1.62  1.34  1.44  1.45     -  1.59  1.51  2.01  1.54  1.53  1.29  1.32  1.41 L 1.51 0.18 12
S  LBL  LOO     DICOT    2.21  1.67  2.06     -  1.64  1.50  1.69     -  1.87  1.58     -     -     -  1.38  1.37  1.42 S 1.67 0.28 16
G  UCD  CAHILL  SMDAY       -  0.54  0.47  0.74  0.56  0.46  0.55  0.86  0.71  0.43  0.58     -     -     -     -     - G 0.59 0.14 23
I  UCD  CAHILL  SFU      0.52  0.59  0.35  0.50  0.50  0.51  0.55  0.85  0.61  0.38  0.60  0.50  0.67  0.77  0.34  0.78 I 0.56 0.15 27

  MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION    0.71  0.43  0.59  0.41  0.42  0.41  0.39  0.26  0.47  0.45  0.69  0.41  0.35  0.26  0.36  0.31    0.43

REGRESSION VS Z         INTERCEPT      ERROR       SLOPE       ERROR  RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY  MDS-A     -89.030    110.273       0.838       0.076    90.374       0.968
M  EPA  DZUBAY   TF-M    -416.830    324.095       1.192       0.230   259.880       0.831
N  EPA  DZUBAY   TF-P    -230.279    388.208       1.133       0.276   344.794       0.751
R  EPA  DZUBAY  MDS-S     100.328    168.438       0.709       0.118   152.454       0.849
C  LBL  LOO     DICOT     300.208    354.726       1.142       0.240   292.824       0.833
L  LBL  LOO     DICOT     540.858    250.927       1.109       0.173   216.263       0.871
S  LBL  LOO     DICOT     629.590    439.063       1.192       0.300   359.384       0.798
G  UCD  CAHILL  SMDAY     233.377    208.362       0.394       0.154   162.305       0.670
I  UCD  CAHILL  SFU       196.469    244.331       0.414       0.171   221.144       0.543
```

```
 '                  INTERCOMPARISON STUDY OF TOTAL CU  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS           PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A       39   172     -   381    52     -    59     -   -98     -     -   184   111     -    62   125 D
M  EPA  DZUBAY   TF-M       32   124    20   444    62    45    36     -    21    26    29   129    57   215     -    65 M
N  EPA  DZUBAY   TF-P       26   112    20   372     -    32    29    53    11    13     7   138    59   226    87    64 N
R  EPA  DZUBAY  MDS-S       23   120    29   386    45    53    36    68    20    33    36   151    56   115    46    95 R
C  LBL  LOO     DICOT        -     -     -   469    42   102    45     -    44    68    61   223    76   305    60   121 C
L  LBL  LOO     DICOT       20   115    30   418    25    25    17     -    10    14    18   155    46   265    30    61 L
S  LBL  LOO     DICOT       46   150    45     -    57    83    56     -    39    52     -     -     -   311    65   138 S
G  UCD  CAHILL  SMDAY        -    85    14   359    14    19    11    35    17    22    28     -     -     -     -     - G
H  UCD  CAHILL  TTLF        11    72    11   275    16    26    11    26    13    16     8   109    31   180    19    45 H
I  UCD  CAHILL  SFU          -    91     -   342    56    19    52     -     -     -     -   120     -   211     -     - I
J  FSU  HUDSON  LS .2        -     -     -   340    16    12    11    39    17    30    15   167    44   283    30    65 J
K  FSU  HUDSON  LS .4        -     -     -   519    34    34    23    38    29    31    25   198    63   291    30    65 K

Z MEAN(WITHOUT I)           28   119    24   396    36    43    30    43    30    31    25   162    60   243    48    84     88   40
   STANDARD DEVIATION       12    32    12    69    18    29    18    15    25    18    17    36    23    65    22    33

X MEAN(D,M,L,G,K)           30   124    21   424    37    31    29    37    35    23    25   167    69   257    41    79
   STANDARD DEVIATION       10    36     8    62    20    11    19     2    36     7     5    31    29    39    18    31

RATIO TO Z        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A   1.39  1.45     - •0.96  1.43     -  1.94     -  3.30     -     -  1.14  1.84     -  1.30  1.48 D 1.62 0.66 40
M  EPA  DZUBAY   TF-M  •1.14 •1.04  0.83  1.12  1.71 •1.04  1.19     -  0.71  0.85 •1.15  0.80 •0.95  0.88     -  0.77 M 1.01 0.25 25
N  EPA  DZUBAY   TF-P  •0.92 •0.94 •0.83  0.94     -  0.74 •0.96  1.23  0.37  0.43  0.28  0.85 •0.98  0.93  1.83  0.76 N 0.87 0.37 43
R  EPA  DZUBAY  MDS-S   0.82 •1.01  1.20 •0.97  1.24  1.23  1.19  1.58 •0.94 •1.08  1.43  0.94  0.93  0.47 •0.97  1.13 R 1.07 0.25 24
C  LBL  LOO     DICOT      -     -     -  1.18  1.16  2.37  1.48     -  1.48  2.23  2.42  1.38  1.26  1.25  1.26  1.43 C 1.58 0.47 30
L  LBL  LOO     DICOT   0.71 •0.97  1.24 •1.06  0.69  0.58  0.56     -  0.34  0.46  0.71 •0.96  0.76 •1.09  0.63  0.72 L 0.77 0.25 33
S  LBL  LOO     DICOT   1.63  1.26  1.86     -  1.57  1.93  1.84     -  1.31  1.71     -     -     -  1.28  1.36  1.64 S 1.58 0.25 16
G  UCD  CAHILL  SMDAY      -  0.72  0.58 •0.91  0.39  0.44  0.36  0.81  0.57  0.72 •1.11     -     -     -     -     - G 0.66 0.24 36
H  UCD  CAHILL  TTLF    0.39  0.61  0.46  0.69  0.44  0.60  0.36  0.60  0.44  0.52  0.32  0.68  0.51  0.74  0.40  0.53 H 0.52 0.13 24
I  UCD  CAHILL  SFU        -  0.77     - •0.86  1.54  0.44  1.71     -     -     -     -  0.74     - •0.87     -     - I 0.99 0.46 46
J  FSU  HUDSON  LS .2      -     -     -  0.86  0.44  0.28  0.36 •0.90  0.57 •0.98  0.60 •1.03  0.73  1.16  0.63  0.77 J 0.72 0.27 37
K  FSU  HUDSON  LS .4      -     -     -  1.31 •0.94  0.79 •0.76 •0.88 •0.98 •1.02 •0.99  1.23 •1.04  1.20  0.63  0.77 K 0.96 0.20 21

  MEAN(WITHOUT I)       1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION   0.42  0.27  0.48  0.18  0.49  0.67  0.58  0.35  0.85  0.57  0.66  0.22  0.38  0.27  0.47  0.39   0.45

REGRESSION VS Z        INTERCEPT      ERROR      SLOPE      ERROR   RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY  MDS-A     40.931      9.362      0.879      0.064    21.739      0.979
M  EPA  DZUBAY   TF-M     -4.880      7.383      1.047      0.053    20.544      0.985
N  EPA  DZUBAY   TF-P     -2.225      5.437      0.938      0.040    15.644      0.988
R  EPA  DZUBAY  MDS-S      9.848     10.113      0.828      0.077    30.258      0.945
C  LBL  LOO     DICOT     20.688      6.429      1.150      0.044    16.522      0.993
L  LBL  LOO     DICOT    -16.667      3.147      1.102      0.023     9.086      0.997
S  LBL  LOO     DICOT     15.330      4.547      1.219      0.050    10.467      0.992
G  UCD  CAHILL    DAY    -11.579      3.684      0.926      0.027     9.495      0.997
H  UCD  CAHILL    LF      -8.723      1.665      0.730      0.013     4.982      0.998
I  UCD  CAHILL  SFU        0.         0.         0.         0.        0.          0.
J  FSU  HUDSON  LS .2    -10.413      8.409      0.978      0.059    22.638      0.981
K  FSU  HUDSON  LS .4    -20.076      4.515      1.332      0.032    12.154      0.997
```

```
1                         INTERCOMPARISON STUDY OF SMALL CU  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A    24   129    21   357    23     -    28    68    42    29    24   154    53     -    29    86 D
M  EPA  DZUBAY   TF-M    14   106    12   394    24    28    20     -     9    17    19   115    37   200    33    51 M
N  EPA  DZUBAY   TF-P    26    94    14   339    18    26    12    42    11    12     5   122    31   206    52    53 N
R  EPA  DZUBAY  MDS-S    16   103    20   358    29    38    24    52    18    23    20   138    43   192    33    72 R
C  LBL  LOO     DICOT    24     -     -   445    30    82    34     -    35    55    46   200    62   287    47   101 C
L  LBL  LOO     DICOT    14   107    24   400    18    18    12     -     7     9    11   145    38   253    23    52 L
S  LBL  LOO     DICOT    26   135    32     -    41    63    41     -    28    39    44   183    79   289    50   113 S
G  UCD  CAHILL  SMDAY     8    78     7   359    14    17     5    27    17    16    16     -     -     -     -     - G
I  UCD  CAHILL  SFU       -    81     -   296    37     -    35     -     -     -     -   120     -   180     -     - I

Z MEAN(WITHOUT I)        19   107    19   379    25    39    22    47    21    25    23   151    49   238    38    75     80   31
   STANDARD DEVIATION     7    20     8    36     9    25    12    17    13    16    15    31    17    44    11    25

X MEAN(D,M,L,G)          15   105    16   378    20    21    16    48    19    18    18   138    43   227    28    63
   STANDARD DEVIATION     7    21     8    23     5     6    10    29    16     8     5    20     9    37     5    20

RATIO TO Z     PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A  1.26  1.20  1.13  0.94 •0.93     -  1.27  1.44  2.01  1.16 •1.04 •1.02  1.08     -  0.76  1.14 D 1.17 0.29 25
M  EPA  DZUBAY   TF-M  0.74 •0.99  0.65 •1.04 •0.97  0.72 •0.91     -  0.43  0.68  0.82  0.76  0.76  0.84  0.87  0.68 M 0.79 0.16 20
N  EPA  DZUBAY   TF-P  1.37  0.88  0.75  0.90  0.73  0.67  0.55  0.89  0.53  0.48  0.22  0.81  0.63  0.87  1.36  0.70 N 0.77 0.29 38
R  EPA  DZUBAY  MDS-S  0.84 •0.96 •1.08  0.95  1.18 •0.98  1.09  1.10  0.86  0.92  0.87  0.91  0.88  0.81  0.87 •0.95 R 0.95 0.11 11
C  LBL  LOO     DICOT  1.26     -     -  1.17  1.22  2.11  1.55     -  1.68  2.20  1.99  1.32  1.27  1.21  1.23  1.34 C 1.50 0.37 25
L  LBL  LOO     DICOT  0.74 •1.00  1.29 •1.06  0.73  0.46  0.55     -  0.34  0.36  0.48 •0.96  0.78 •1.06  0.60  0.69 L 0.74 0.29 39
S  LBL  LOO     DICOT  1.37  1.26  1.72     -  1.67  1.62  1.86     -  1.34  1.56  1.90  1.21  1.61  1.22  1.31  1.50 S 1.51 0.23 15
G  UCD  CAHILL  SMDAY  0.42  0.73  0.38 •0.95  0.57  0.44  0.23  0.57  0.81  0.64  0.69     -     -     -     -     - G 0.58 0.21 36
I  UCD  CAHILL  SFU       -  0.75     -  0.78  1.50     -  1.59     -     -     -     -  0.80     -  0.76     -     - I 1.03 0.40 39

  MEAN(WITHOUT I)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.36  0.18  0.45  0.10  0.35  0.63  0.55  0.37  0.61  0.62  0.64  0.21  0.34  0.19  0.30  0.34   0.39

REGRESSION VS Z        INTERCEPT     ERROR     SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A      9.382     3.507     0.935      0.030    10.412      0.994
M  EPA  DZUBAY   TF-M     -9.850     4.755     0.998      0.037    14.203      0.991
N  EPA  DZUBAY   TF-P     -5.088     2.969     0.896      0.024     9.155      0.995
R  EPA  DZUBAY  MDS-S      1.385     2.681     0.906      0.021     8.267      0.996
C  LBL  LOO     DICOT     13.702     4.044     1.151      0.030    11.337      0.996
L  LBL  LOC     DICOT    -14.179     2.816     1.093      0.022     8.413      0.997
S  LBL  LOO     DICOT     12.240     2.541     1.165      0.029     6.784      0.996
G  UCD  CAHILL  SMDAY    -12.751     2.620     0.971      0.022     7.296      0.998
I  UCD  CAHILL  SFU       0.        0.        0.         0.        0.          0.
```

```
1                    INTERCOMPARISON STUDY OF LARGE CU  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG.   SD

D  EPA  DZUBAY  MDS-A      15   -43     -    24    29     -    31     -   -56     -     -    30    58     -    39    39 D
M  EPA  DZUBAY   TF-M      18    18     8    50    38    17    16     -    12     9    10    14    20    15     -    14 M
N  EPA  DZUBAY   TF-P       0    18     6    33     -     6    17    11     0     1     2    16    28    20    35    11 N
R  EPA  DZUBAY  MDS-S       7    17     9    28    16    15    12    16    10    10    16    13    13    23    13    23 R
C  LBL  LOO     DICOT       -     -     -    24    12    20    11     -     9    13    15    23    14    18    13    20 C
L  LBL  LOO     DICOT       6     8     6    18     7     7     5     -     3     5     7    10     8    12     7     9 L
S  LBL  LOO     DICOT      20    15    13     -    16    20    15     -    11    13     -     -     -    23    15    25 S
G  UCD  CAHILL  SMDAY       -     7     7     -     -     -     6     -     -     6    12     -     -     -     -     - G
I  UCD  CAHILL  SFU         -     -     -    46    19    19    17     -     -     -     -     -     -    31     -     - I

Z MEAN(WITHOUT G,I)        11    20     8    30    20    14    15    14    14     9    10    18    24    19    20    20      17     9
   STANDARD DEVIATION       8    12     3    11    12     6     8     4    19     5     6     7    18     4    13    10

X MEAN(D,M,L)              13    23     7    31    25    12    17     -    24     7     9    18    29    14    23    21
   STANDARD DEVIATION       6    18     1    17    16     7    13     0    28     3     2    11    26     2    23    16

RATIO TO Z      PERIOD      1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG    SD CV

D  EPA  DZUBAY  MDS-A    1.36  2.17     -  0.81  1.47     -  2.03     -  3.88     -     -  1.70  2.47     -  1.92  1.94 D 1.98 0.81 41
M  EPA  DZUBAY   TF-M    1.64 •0.91 •0.95  1.70  1.93 •1.20 •1.05     - •0.83 •1.06 •1.00  0.79  0.85  0.81     -  0.70 M 1.10 0.38 35
N  EPA  DZUBAY   TF-P    0.   •0.91 •0.71 •1.12     -  0.42 •1.11 •0.82  0.    0.12  0.20 •0.91  1.19 •1.08  1.72  0.55 N 0.72 0.50 69
R  EPA  DZUBAY  MDS-S    0.64  0.86 •1.07 •0.95  0.81 •1.06  0.79  1.19  0.69 •1.18  1.60  0.74  0.55  1.24  0.64 •1.14 R 0.95 0.28 30
C  LBL  LOO     DICOT       -     -     -  0.81  0.61  1.41  0.72     -  0.62  1.53  1.50  1.30  0.60 •0.97  0.64 •0.99 C 0.98 0.37 38
L  LBL  LOO     DICOT    0.55  0.40  0.71  0.61  0.36  0.49  0.33     -  0.21  0.59  0.70  0.57  0.34  0.65  0.34  0.45 L 0.49 0.15 32
S  LBL  LOO     DICOT    1.82  0.76  1.55     -  0.81  1.41 •0.98     -  0.76  1.53     -     -     -  1.24  0.74  1.24 S 1.17 0.38 33
G  UCD  CAHILL  SMDAY       -  0.35 •0.83     -     -     -  0.39     -     -  0.71 •1.20     -     -     -     -     - G 0.70 0.35 50
I  UCD  CAHILL  SFU         -     -     -  1.56 •0.97 •1.34 •1.11     -     -     -     -     -     -  1.68     -     - I 1.33 0.30 22

  MEAN(WITHOUT G,I)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION    0.71  0.60  0.34  0.38  0.59  0.44  0.52  0.26  1.31  0.56  0.58  0.42  0.78  0.24  0.65  0.51   0.56

REGRESSION VS Z          INTERCEPT      ERROR       SLOPE      ERROR  RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY  MDS-A       29.544     18.291       0.358      0.927    14.205       0.135
M  EPA  DZUBAY   TF-M       -5.642      6.315       1.466      0.362     7.850       0.760
N  EPA  DZUBAY   TF-P      -13.962      5.013       1.689      0.290     6.385       0.850
R  EPA  DZUBAY  MDS-S        3.804      3.282       0.681      0.188     4.186       0.695
C  LBL  LOO     DICOT        9.476      4.468       0.370      0.242     4.608       0.435
L  LBL  LOO     DICOT        0.573      2.034       0.436      0.115     2.535       0.724
S  LBL  LOO     DICOT       11.205      4.796       0.360      0.298     4.346       0.381
G  UCD  CAHILL  SMDAY        0.         0.          0.         0.        0.          0.
I  UCD  CAHILL  SFU          0.         0.          0.         0.        0.          0.
```

1 INTERCOMPARISON STUDY OF TOTAL ZN : NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS	PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD
D EPA DZUBAY	MDS-A	100	298	-	214	108	-	86	-	81	-	-	89	108	-	80	90	D		
M EPA DZUBAY	TF-M	82	294	126	274	140	117	89	-	65	81	74	104	113	116	-	87	M		
N EPA DZUBAY	TF-P	95	292	108	239	-	113	63	-238	61	70	65	110	105	119	104	96	N		
R EPA DZUBAY	MDS-S	76	247	104	193	95	89	65	86	66	63	71	89	74	85	75	71	R		
C LBL LOO	DICOT	-	-	-	202	129	133	81	-	52	67	99	125	108	130	79	95	C		
L LBL LOO	DICOT	101	339	135	209	124	122	84	-	50	71	100	118	111	137	79	93	L		
S LBL LOO	DICOT	107	344	187	-	134	122	96	-	57	73	-	-	-	137	80	88	S		
G UCD CAHILL	SMDAY	-	236	99	238	98	84	61	102	47	60	74	-	-	-	-	-	G		
H UCD CAHILL	TTLF	69	241	110	231	91	86	68	84	40	56	60	107	83	102	71	78	H		
I UCD CAHILL	SFU	63	254	95	222	90	92	77	102	62	49	93	103	92	123	52	78	I		
J FSU HUDSON	LS .2	-	-	-	200	126	99	91	83	82	64	106	95	112	98	81	68	J		
K FSU HUDSON	LS .4	-	-	-	304	140	117	127	113	80	65	103	98	122	115	88	72	K		
Z MEAN(ALL SAMPLERS)		87	283	121	242	116	107	82	115	62	65	85	104	103	116	79	83		116	22
STANDARD DEVIATION		16	41	30	36	20	17	18	55	14	9	17	12	15	17	13	10			
X MEAN(D,M,L,G,I,K)		87	284	114	254	117	106	87	106	64	65	89	102	109	123	75	84			
STANDARD DEVIATION		18	40	20	35	21	17	22	6	14	12	14	11	11	10	16	9			

RATIO TO Z	PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		AVG	SD	CV
D EPA DZUBAY	MDS-A	1.15	1.05	-	0.88	0.93	-	•1.04	-	1.31	-	-	0.86	•1.05	-	•1.01	1.08	D	1.04	0.13	13
M EPA DZUBAY	TF-M	•0.95	•1.04	•1.05	1.13	1.21	1.10	•1.08	-	•1.05	1.24	0.88	•1.00	1.10	•1.00	-	•1.05	M	1.06	0.10	9
N EPA DZUBAY	TF-P	1.10	•1.03	0.90	•0.99	-	•1.06	0.77	2.06	•0.99	•1.07	0.77	•1.06	•1.02	•1.02	1.32	1.15	N	1.09	0.30	28
R EPA DZUBAY	MDS-S	0.88	0.87	0.86	0.80	0.82	0.83	0.79	0.75	1.07	•0.96	0.84	0.86	0.72	0.73	•0.95	0.85	R	0.85	0.09	11
C LBL LOO	DICOT	-	-	-	1.16	1.11	1.25	•0.98	-	0.84	•1.03	1.17	1.20	•1.05	1.12	•1.00	1.14	C	1.09	0.11	10
L LBL LOO	DICOT	1.17	1.20	1.12	•1.11	•1.07	1.14	•1.02	-	0.81	•1.09	1.18	1.14	•1.08	1.18	•1.00	1.12	L	1.09	0.10	9
S LBL LOO	DICOT	1.24	1.22	1.55	-	1.16	1.14	1.17	-	•0.92	1.12	-	-	-	1.18	•1.01	•1.06	S	1.16	0.16	14
G UCD CAHILL	SMDAY	-	0.83	0.82	•0.98	0.85	0.79	0.74	0.88	0.76	•0.92	0.88	-	-	-	-	-	G	0.85	0.07	9
H UCD CAHILL	TTLF	0.80	•0.85	•0.91	•0.95	0.79	0.81	0.83	0.73	0.65	•0.86	0.71	•1.03	0.81	•0.88	•0.90	•0.94	H	0.84	0.10	12
I UCD CAHILL	SFU	0.73	•0.90	0.79	•0.92	0.78	0.86	•0.94	0.88	•1.00	0.75	•1.10	•0.99	•0.90	•1.06	0.66	•0.94	I	0.89	0.12	14
J FSU HUDSON	LS .2	-	-	-	0.83	•1.09	•0.93	•1.11	0.72	1.32	•0.98	1.25	•0.92	•1.09	0.84	•1.03	0.82	J	0.99	0.18	18
K FSU HUDSON	LS .4	-	-	-	1.25	•1.21	•1.10	1.54	•0.98	1.29	•0.99	1.22	•0.94	1.19	•0.99	•1.12	•0.86	K	1.13	0.18	16
MEAN(ALL SAMPLERS)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		
STANDARD DEVIATION		0.19	0.15	0.25	0.15	0.17	0.16	0.22	0.48	0.22	0.13	0.21	0.11	0.15	0.15	0.17	0.12		0.19		

REGRESSION VS Z		INTERCEPT	ERROR	SLOPE	ERROR	RMS.DEV.	COR.COEFF.
D EPA DZUBAY	MDS-A	8.286	9.442	0.944	0.066	14.876	0.981
M EPA DZUBAY	TF-M	-2.456	5.719	1.085	0.043	9.930	0.991
N EPA DZUBAY	TF-P	8.851	19.260	1.007	0.148	34.653	0.884
R EPA DZUBAY	MDS-S	1.977	4.653	0.820	0.036	8.427	0.987
C LBL LOO	DICOT	-12.969	5.853	1.234	0.052	8.117	0.991
L LBL LOO	DICOT	-10.924	4.206	1.209	0.032	7.565	0.995
S LBL LOO	DICOT	-10.391	10.274	1.282	0.083	16.047	0.982
G UCD CAHILL	SMDAY	-7.695	7.250	0.920	0.050	11.110	0.989
H UCD CAHILL	TTLF	-8.150	5.595	0.923	0.043	10.134	0.985
I UCD CAHILL	SFU	-2.860	6.341	0.915	0.049	11.485	0.981
J FSU HUDSON	LS .2	27.372	10.184	0.698	0.090	14.137	0.920
K FSU HUDSON	LS .4	-13.712	12.645	1.267	0.112	17.553	0.960

```
I                 INTERCOMPARISON STUDY OF SMALL ZN  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS           PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG    SD

D  EPA  DZUBAY  MDS-A       57   239    74   170    61     -    45    74    41    30    39    64    62     -    34    54 D
M  EPA  DZUBAY   TF-M       64   244    84   210    74    66    49     -    39    46    55    71    61    70    47    53 M
N  EPA  DZUBAY   TF-P       74   248    65   178    66    55    27  -177    31    24    37    67    51    77    52    53 N
R  EPA  DZUBAY  MDS-S       49   222    70   165    58    58    34    58    32    33    36    66    45    57    39    43 R
C  LBL  LOO     DICOT       54     -     -   210    65    61    39     -    31    34    42    76    57    88    38    53 C
L  LBL  LOO     DICOT       51   278    80   203    63    58    38     -    27    30    37    70    56    90    34    49 L
S  LBL  LOO     DICOT       46   285  -114     -    62    55    39     -    27    32     -    75     -    85    35    46 S
G  UCD  CAHILL  SMDAY       52   220    84   220    75    64    45    80    36    47    53     -     -     -     -     - G
I  UCD  CAHILL  SFU         45   209    69   175    61    50    38    68    28    28    50    80    41    73    27    47 I

Z MEAN(ALL SAMPLERS)        55   243    80   191    65    58    39    91    32    34    44    71    53    77    38    50      76    13
   STANDARD DEVIATION        9    27    15    22     6     5     7    49     5     8     8     6     8    12     8     4

X MEAN(D,M,L,G,I)           54   238    78   196    67    60    43    74    34    36    47    71    55    78    36    51
   STANDARD DEVIATION        7    26     7    22     7     7     5     6     6     9     8     7    10    11     8     3

RATIO TO Z        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A    •1.04 •0.98  0.93  0.89  0.94     -  1.14  0.81  1.26  0.89  0.89  0.90  1.16     -  0.89  1.09 D 0.99 0.13 13
M  EPA  DZUBAY   TF-M     1.17 •1.00 •1.05  1.10  1.14  1.13  1.25     -  1.20  1.36  1.26 •1.00  1.15  0.91  1.23 •1.07 M 1.13 0.12 10
N  EPA  DZUBAY   TF-P     1.35 •1.02  0.81  0.93 •1.02 •0.94  0.69  1.94 •0.96  0.71  0.85 •0.94 •0.96 •1.00  1.36 •1.07 N 1.03 0.30 29
R  EPA  DZUBAY  MDS-S     0.90  0.91  0.88  0.86  0.89 •0.99  0.86  0.63 •0.99 •0.98  0.83  0.93  0.84  0.74 •1.02  0.86 R 0.88 0.10 11
C  LBL  LOO     DICOT    •0.99     -     - •1.10 •1.00 •1.05 •0.99     - •0.96 •1.01 •0.96 •1.07 •1.07  1.14 •0.99 •1.07 C 1.03 0.06  5
L  LBL  LOO     DICOT    •0.93  1.14 •1.00 •1.06 •0.97 •0.99 •0.97     -  0.83  0.89  0.85 •0.98 •1.05  1.17  0.89 •0.99 L 0.98 0.10 10
S  LBL  LOO     DICOT     0.84  1.17  1.43     - •0.95 •0.94 •0.99     -  0.83 •0.95     - •1.05     - •1.10 •0.92 •0.92 S 1.01 0.16 16
G  UCD  CAHILL  SMDAY    •0.95 •0.91 •1.05 •1.15 •1.15 •1.10 •1.14 •0.88 •1.11  1.39  1.22     -     -     -     -     - G 1.10 0.15 14
I  UCD  CAHILL  SFU       0.82  0.86  0.86 •0.91 •0.94  0.86 •0.97  0.74  0.86  0.83 •1.15 •1.13  0.77 •0.95  0.71 •0.95 I 0.89 0.12 13

  MEAN(ALL SAMPLERS)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION     0.17  0.11  0.19  0.11  0.09  0.09  0.17  0.53  0.16  0.23  0.18  0.08  0.15  0.15  0.21  0.08    0.17

REGRESSION VS Z            INTERCEPT      ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A          2.681      3.391      0.926      0.035     7.774      0.992
M  EPA  DZUBAY   TF-M          7.056      2.652      0.996      0.028     6.277      0.995
N  EPA  DZUBAY   TF-P          2.585     10.314      1.015      0.109    24.532      0.928
R  EPA  DZUBAY  MDS-S         -0.847      3.196      0.882      0.034     7.602      0.990
C  LBL  LOO     DICOT         -4.888      1.287      1.128      0.017     2.495      0.999
L  LBL  LOO     DICOT         -9.819      2.001      1.159      0.021     4.737      0.998
S  LBL  LOO     DICOT        -11.507      4.550      1.233      0.051     9.657      0.991
G  UCD  CAHILL  SMDAY          8.313      6.663      0.948      0.062    13.541      0.981
I  UCD  CAHILL  SFU            1.417      3.188      0.872      0.034     7.582      0.990
```

```
I                    INTERCOMPARISON STUDY OF LARGE ZN  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A       43    59     -    44    47     -    41     -    40     -     -    25    46     -    46    36 D
M  EPA  DZUBAY   TF-M       18    50    42    64    66    51    40     -    26    35    19    33    52    46     -    34 M
N  EPA  DZUBAY   TF-P       21    44    43    61     -    58    36    61    30    46    28    43    54    42    52    43 N
R  EPA  DZUBAY  MDS-S       27    25    34    28    37    31    31    28    34    30    35    23   -29    28    36    28 R
C  LBL  LOO     DICOT        -     -     -    71    64    67    43     -    21    33    57    49    51    42    41    42 C
L  LBL  LOO     DICOT       50    61    55    66    61    64    46     -    22    40    63    48    55    47    45    44 L
S  LBL  LOO     DICOT       61    59    34     -    72    67    57     -    30    41     -     -     -    52    45    42 S
G  UCD  CAHILL  SMDAY        -    16    15    18    23    20    16    22    11    13    21     -     -     -     -     - G
I  UCD  CAHILL  SFU         18    45    26    47    29    42    39    34    34    21    43    23    51    50    25    31 I

Z MEAN(ALL SAMPLERS)        34    45    36    50    50    50    39    36    28    32    38    35    48    44    41    38      40   13
   STANDARD DEVIATION       17    17    13    19    19    18    11    17     9    11    17    12     9     6     9     6

X MEAN(D,M,L,G,I)           32    46    35    48    45    44    36    28    27    27    37    32    51    48    39    36
   STANDARD DEVIATION       17    18    18    19    19    19    12     8    11    12    21    11     4     2    12     6

RATIO TO Z      PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A     1.27  1.32     -  0.88 •0.94     - •1.06     -  1.45     -     -  0.72 •0.95     -  1.11 •0.96 D  1.07 0.22 21
M  EPA  DZUBAY   TF-M     0.53 •1.11  1.18  1.28  1.32 •1.02 •1.03     - •0.94 •1.08  0.50 •0.95 •1.08 •1.05     - •0.91 M  1.00 0.24 24
N  EPA  DZUBAY   TF-P     0.62 •0.98  1.21  1.22     -  1.16 •0.93  1.68 •1.09  1.42  0.74  1.23 •1.12 •0.96  1.26  1.15 N  1.12 0.26 23
R  EPA  DZUBAY  MDS-S     0.79  0.56 •0.96  0.56  0.74  0.62  0.80  0.77  1.23 •0.93  0.92  0.66  0.60  0.64  0.87  0.75 R  0.78 0.18 23
C  LBL  LOO     DICOT        -     -     -  1.42  1.28  1.34  1.11     -  0.76 •1.02  1.50  1.41 •1.06 •0.96 •0.99  1.12 C  1.16 0.23 19
L  LBL  LOO     DICOT     1.47  1.36  1.55  1.32  1.22  1.28  1.19     -  0.80  1.24  1.66  1.38  1.14 •1.07 •1.09  1.17 L  1.26 0.21 17
S  LBL  LOO     DICOT     1.79  1.32 •0.96     -  1.44  1.34  1.47     - •1.09  1.27     -     -     -  1.19 •1.09  1.12 S  1.28 0.23 18
G  UCD  CAHILL  SMDAY        -  0.36  0.42  0.36  0.46  0.40  0.41  0.61  0.40  0.40  0.55     -     -     -     -     - G  0.44 0.08 19
I  UCD  CAHILL  SFU       0.53 •1.00  0.73 •0.94  0.58  0.84 •1.01 •0.94 •1.23  0.65 •1.13  0.66 •1.06 •1.14  0.60  0.83 I  0.87 0.22 26

   MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION     0.51  0.37  0.36  0.38  0.37  0.35  0.29  0.48  0.31  0.34  0.45  0.34  0.19  0.18  0.21  0.16    0.33

REGRESSION VS Z          INTERCEPT     ERROR     SLOPE     ERROR  RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY  MDS-A       18.062    14.317     0.605     0.346     7.821       0.526
M  EPA  DZUBAY   TF-M      -27.251    12.918     1.693     0.315     8.376       0.841
N  EPA  DZUBAY   TF-P        0.928    15.710     1.092     0.392     9.799       0.612
R  EPA  DZUBAY  MDS-S       29.441     6.303     0.020     0.155     4.164       0.035
C  LBL  LOO     DICOT      -18.534    13.876     1.632     0.333     8.288       0.840
L  LBL  LOO     DICOT        0.743    11.862     1.246     0.289     7.692       0.767
S  LBL  LOO     DICOT       -8.510    15.555     1.500     0.387     8.763       0.791
G  UCD  CAHILL  SMDAY        4.686     5.597     0.318     0.136     3.258       0.636
I  UCD  CAHILL  SFU         -2.295    13.407     0.925     0.329     8.856       0.601
```

```
1                    INTERCOMPARISON STUDY OF TOTAL SE  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A     10     9    13     8     6     -     8     7     2     8    26    17    21     -    12     6 D
M  EPA  DZUBAY   TF-M      8   -22    19    11    13     8    10     -    -6    11   -36    21    23   -17     9     9 M
N  EPA  DZUBAY   TF-P      5     8     8     4     -     3     6     6     -     4    24    15    17    12    11     7 N
R  EPA  DZUBAY  MDS-S     10     9    15     7     8     7     7     8     3    10    27     8    18    12    12     5 R
C  LBL  LOO     DICOT      -     -     -     7     5     2     4     -     2     7    27    15    21    10     9     5 C
L  LBL  LOO     DICOT      7     8    14     6     5     4     4     -     3     8    27    13    21    12     9     5 L
S  LBL  LOO     DICOT      7     8    14     -     4     3     5     -     3     7     -     -     -    10     9     5 S
G  UCD  CAHILL  SMDAY      -     -     9     -     -     -     -     -     -     6    25     -     -     -     -     - G
H  UCD  CAHILL  TTLF       7     7    11     -     -     -     6     -     -     8    24    14    16    11     8     7 H
I  UCD  CAHILL  SFU        -     -    22     -     -     -     -     -     -     -    27    27    23     -     -     - I

Z MEAN(WITHOUT G,I)        8    10    13     7     7     5     6     7     3     8    27    15    20    12    10     6     10    3
   STANDARD DEVIATION      2     5     3     2     3     2     2     1     1     2     4     4     3     2     2     1

X MEAN(D,M,L)              8    13    15     8     8     6     7     7     4     9    30    17    22    15    10     7
   STANDARD DEVIATION      2     8     3     3     4     3     3     0     2     2     6     4     1     4     2     2

RATIO TO Z       PERIOD    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A  1.30 *0.89 *0.97 *1.12 *0.88     - *1.28 *1.00 *0.63 *1.02 *0.95  1.16 *1.07     -  1.22 *0.98 D 1.03 0.18 17
M  EPA  DZUBAY   TF-M *1.04  2.17  1.42  1.54  1.90  1.78  1.60     -  1.90  1.40  1.32  1.43  1.18  1.42 *0.91  1.47 M 1.50 0.34 22
N  EPA  DZUBAY   TF-P  0.65  0.79  0.60  0.56     - *0.67 *0.96 *0.86     -  0.51  0.88 *1.02  0.87 *1.00 *1.11 *1.14 N 0.83 0.21 25
R  EPA  DZUBAY  MDS-S  1.30 *0.89 *1.12 *0.98 *1.17  1.56 *1.12 *1.14 *0.95  1.27 *0.99  0.54 *0.92 *1.00  1.22 *0.82 R 1.06 0.23 22
C  LBL  LOO     DICOT     -     -     - *0.98  0.73  0.44  0.64     -  0.63 *0.89 *0.99 *1.02 *1.07  0.83 *0.91  0.82 C 0.83 0.19 23
L  LBL  LOO     DICOT *0.91  0.79 *1.04  0.84  0.73 *0.89  0.64     - *0.95 *1.02 *0.99  0.88 *1.07 *1.00 *0.91  0.82 L 0.90 0.12 13
S  LBL  LOO     DICOT *0.91  0.79 *1.04     -  0.59  0.67  0.80     - *0.95 *0.89     -     -     -  0.83 *0.91  0.82 S 0.84 0.13 15
G  UCD  CAHILL  SMDAY     -     -  0.67     -     -     -     -     -     - *0.76 *0.92     -     -     -     -     - G 0.78 0.12 16
H  UCD  CAHILL  TTLF  *0.91  0.69 *0.82     -     -     - *0.96     -     - *1.02 *0.88 *0.95 *0.82 *0.92 *0.81 *1.14 H 0.90 0.12 13
I  UCD  CAHILL  SFU       -     - *1.64     -     -     -     -     -     -     - *0.99  1.84 *1.18     -     -     - I 1.41 0.39 28

  MEAN(WITHOUT G,I)    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.23  0.52  0.25  0.32  0.48  0.54  0.33  0.14  0.47  0.27  0.15  0.27  0.13  0.20  0.16  0.24   0.29

REGRESSION VS Z         INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV.  COR.COEFF.
D  EPA  DZUBAY  MDS-A       0.536     0.738      0.989      0.061     1.399      0.978
M  EPA  DZUBAY   TF-M       2.312     1.511      1.202      0.125     2.954      0.936
N  EPA  DZUBAY   TF-P      -0.729     1.087      0.912      0.087     1.948      0.950
R  EPA  DZUBAY  MDS-S       1.478     1.078      0.870      0.091     2.174      0.931
C  LBL  LOO     DICOT      -1.985     0.504      1.099      0.041     0.946      0.993
L  LBL  LOO     DICOT      -1.350     0.510      1.061      0.042     0.998      0.990
S  LBL  LOO     DICOT      -1.399     0.858      1.028      0.101     0.992      0.959
G  UCD  CAHILL  SMDAY       0.        0.         0.         0.        0.         0.
H  UCD  CAHILL  TTLF        0.630     0.736      0.830      0.054     1.088      0.982
I  UCD  CAHILL  SFU         0.        0.         0.         0.        0.         0.
```

```
1                INTERCOMPARISON STUDY OF SMALL SE  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16      AVG     SD

D  EPA  DZUBAY   MDS-A      8      7     13      7      5      -      6      7      1      8     26     15     19      -     10      5 D
M  EPA  DZUBAY    TF-M      8     11     15     11     10      7      8      -     -6      9    -36     18     22     15      9      8 M
N  EPA  DZUBAY    TF-P      5      5      8      2      1      3      3     -6      1      3     21     12     16      8      8      5 N
R  EPA  DZUBAY   MDS-S      8      8     13      6      6      6      5      7      2      9     24      6     16     12     10      5 R
C  LBL  LOO      DICOT      7      -      -      6      4      2      3      -      2      7     25     14     19      9      8      4 C
L  LBL  LOO      DICOT      6      7     12      5      4      3      3      -      3      7     24     12     19     10      8      4 L
S  LBL  LOO      DICOT      6      7     12      -      3      2      4      -      3      6     25     15     20      9      8      4 S
G  UCD  CAHILL   SMDAY      4      -      9      -      -      -      -      -      -      6     25      -      -      -      -      - G
I  UCD  CAHILL   SFU        -      -     22      -      -      -      -      -      -      -     27     27     23      -      -      - I

Z MEAN(WITHOUT G,I)         7      8     12      6      5      4      5      7      3      7     26     13     19     11      9      5        9      3
  STANDARD DEVIATION        1      2      2      3      3      2      2      1      2      2      5      4      2      3      1      1

X MEAN(D,M,L)               7      8     13      8      6      5      6      7      3      8     29     15     20     13      9      6
  STANDARD DEVIATION        1      2      2      3      3      3      3      0      3      1      6      3      2      4      1      2

RATIO TO Z      PERIOD      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16      AVG     SD     CV

D  EPA  DZUBAY   MDS-A   1.17  •0.93  •1.07  •1.14  •1.06      -   1.31  •1.05   0.39   1.14  •1.01   1.14  •1.02      -   1.15  •1.00 D   1.04   0.21     20
M  EPA  DZUBAY    TF-M   1.17   1.47   1.23   1.78   2.12   1.83   1.75      -   2.33   1.29   1.39   1.37   1.18   1.43  •1.03   1.60 M   1.53   0.37     24
N  EPA  DZUBAY    TF-P  •0.73   0.67   0.66   0.32   0.21  •0.78  •0.66  •0.90   0.39   0.43   0.81  •0.91   0.86   0.76  •0.92  •1.00 N   0.69   0.23     34
R  EPA  DZUBAY   MDS-S   1.17  •1.07  •1.07  •0.97   1.27   1.57  •1.09  •1.05  •0.78   1.29  •0.93   0.46   0.86   1.14   1.15  •1.00 R   1.05   0.24     23
C  LBL  LOO      DICOT  •1.02      -      -  •0.97  •0.85   0.52   0.66      -  •0.78  •1.00  •0.97  •1.07  •1.02   0.86  •0.92   0.80 C   0.88   0.16     18
L  LBL  LOO      DICOT  •0.88  •0.93  •0.99   0.81  •0.85  •0.78   0.66      -  •1.17  •1.00  •0.93   0.91  •1.02  •0.95  •0.92   0.80 L   0.91   0.12     13
S  LBL  LOO      DICOT  •0.88  •0.93  •0.99      -   0.64   0.52  •0.88      -  •1.17   0.86  •0.97  •1.14  •1.07   0.86  •0.92   0.80 S   0.90   0.18     19
G  UCD  CAHILL   SMDAY   0.58      -   0.74      -      -      -      -      -      -  •0.86  •0.97      -      -      -      -      - G   0.79   0.16     21
I  UCD  CAHILL   SFU        -      -   1.81      -      -      -      -      -      -      -  •1.04   2.05  •1.23      -      -      - I   1.53   0.48     31

  MEAN(WITHOUT G,I)      1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00     1.00
  STANDARD DEVIATION     0.18   0.26   0.19   0.47   0.60   0.56   0.42   0.09   0.67   0.30   0.18   0.29   0.11   0.25   0.11   0.28     0.31

REGRESSION VS Z         INTERCEPT      ERROR      SLOPE      ERROR   RMS.DEV. COR.COEFF.
D  EPA  DZUBAY   MDS-A      0.368      0.439      1.017      0.040      0.905      0.991
M  EPA  DZUBAY    TF-M      1.769      0.877      1.212      0.080      1.872      0.973
N  EPA  DZUBAY    TF-P     -1.282      0.630      0.886      0.059      1.379      0.971
R  EPA  DZUBAY   MDS-S      1.646      0.937      0.810      0.087      2.052      0.928
C  LBL  LOO      DICOT     -0.884      0.381      1.033      0.034      0.795      0.994
L  LBL  LOO      DICOT     -0.499      0.305      0.979      0.028      0.651      0.995
S  LBL  LOO      DICOT     -1.048      0.504      1.057      0.045      1.041      0.989
G  UCD  CAHILL   SMDAY      0.         0.         0.         0.         0.         0.
I  UCD  CAHILL   SFU        0.         0.         0.         0.         0.         0.
```

```
1                   INTERCOMPARISON STUDY OF LARGE SE  :  NANOGRAMS/CUBIC METER; PERIODS 1-16. MAY 11-18 1977.

RESULTS           PERIOD    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A       2     2     -     1     1     -     2     -     1     -     -     2     2     -     2     1 D
M  EPA  DZUBAY   TF-M       0   -11     4     0     3     1     2     -     0     2     0     3     1     2     -     1 M
N  EPA  DZUBAY   TF-P       0     3     0     2     -     0     3     0     0     1     3     3     1     4     3     2 N
R  EPA  DZUBAY  MDS-S       2     1     2     1     2     1     2     1     1     1     3     2     2     0     2     0 R
C  LBL  LOO     DICOT       -     -     -     1     1     0     1     -     0     0     2     1     2     1     1     1 C
L  LBL  LOO     DICOT       1     1     2     1     1     1     1     -     0     1     3     1     2     2     1     1 L
S  LBL  LOO     DICOT       1     1     2     -     1     1     1     -     0     1     -     -     -     1     1     1 S
G  UCD  CAHILL  SMDAY       -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     - G
I  UCD  CAHILL  SFU         -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     - I

Z MEAN(WITHOUT G,I)         1     3     2     1     2     1     2     !     0     1     2     2     2     2     2     1      1    1
   STANDARD DEVIATION       1     4     1     1     1     1     1     1     0     1     1     1     1     1     1     1

X MEAN(D,M,L)               1     5     3     1     2     1     2     -     0     2     2     2     2     2     2     1
   STANDARD DEVIATION       1     6     1     1     1     0     1     0     1     1     2     1     1     0     1     0

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A  2.00  0.63     - •1.00 •0.67     - •1.17     - •3.50     -     - •1.00 •1.20     - •1.20 •1.00 D 1.34 0.85 63
M  EPA  DZUBAY   TF-M  0.    3.47  2.00  0.    2.00 •1.50 •1.17     - •0.    2.00  0.    1.50 •0.60 •1.20     - •1.00 M 1.17 1.02 87
N  EPA  DZUBAY   TF-P  0.   •0.95  0.    2.00     - •0.    1.75 •0.   •0.   •1.00 •1.36  1.50 •0.60  2.40  1.80  2.00 N 1.02 0.87 85
R  EPA  DZUBAY  MDS-S  2.00  0.32 •1.00 •1.00 •1.33 •1.50 •1.17 •2.00 •3.50 •1.00 •1.36 •1.00 •1.20  0.   •1.20  0.   R 1.22 0.84 68
C  LBL  LOO     DICOT     -     -     - •1.00 •0.67 •0.   •0.58     - •0.    0.   •0.91  0.50 •1.20 •0.60 •0.60 •1.00 C 0.59 0.41 70
L  LBL  LOO     DICOT •1.00  0.32 •1.00 •1.00 •0.67 •1.50 •0.58     - •0.   •1.00 •1.36  0.50 •1.20 •1.20 •0.60 •1.00 L 0.86 0.41 47
S  LBL  LOO     DICOT •1.00  0.32 •1.00     - •0.67 •1.50 •0.58     - •0.   •1.00     -     -     - •0.60 •0.60 •1.00 S 0.75 0.41 54
G  UCD  CAHILL  SMDAY     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     - G    - 0.    0
I  UCD  CAHILL  SFU       -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     - I    - 0.    0

   MEAN(WITHOUT G,I)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
    STANDARD DEVIATION 0.89  1.24  0.71  0.63  0.56  0.77  0.44  1.41  1.71  0.63  0.59  0.45  0.31  0.82  0.49  0.58   0.77

REGRESSION VS Z        INTERCEPT    ERROR    SLOPE     ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A      0.980    0.311    0.414     0.186    0.431    0.618
M  EPA  DZUBAY   TF-M     -2.245    1.201    2.944     0.728    1.931    0.759
N  EPA  DZUBAY   TF-P     -0.071    0.663    1.210     0.411    1.164    0.632
R  EPA  DZUBAY  MDS-S      0.862    0.446    0.400     0.278    0.786    0.359
C  LBL  LOO     DICOT     -0.337    0.339    0.919     0.231    0.436    0.783
L  LBL  LOO     DICOT      0.536    0.395    0.487     0.239    0.636    0.491
S  LBL  LOO     DICOT      0.592    0.268    0.286     0.167    0.409    0.495
G  UCD  CAHILL  SMDAY      0.       0.       0.        0.       0.       0.
I  UCD  CAHILL  SFU        0.       0.       0.        0.       0.       0.
```

```
1                         INTERCOMPARISON STUDY OF TOTAL BR  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS            PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16   AVG   SD

D  EPA  DZUBAY  MDS-A       159   484     -   279   181     -   114     -    45     -     -   246   123     -   138   207 D
M  EPA  DZUBAY   TF-M       176   690   218   387   278   489   226     -    93   314   314   274   209   263     -   275 M
N  EPA  DZUBAY   TF-P       172   527   191   310     -   421   164   300    51   308   250   240   160   235   242   222 N
R  EPA  DZUBAY  MDS-S       144   479   200   291   187   410   120   292    36   314   271   233   134   218   128   222 R
C  LBL  LOO     DICOT         -     -     -   346   253   422   139     -    53   329   310   343   180   344   185   352 C
L  LBL  LOO     DICOT       192   546   229   352   252   430   157     -    56   344   331   345   188   358   191   351 L
S  LBL  LOO     DICOT       210   597   284     -   289   486   175     -    63   377     -     -     -   413   199   350 S
G  UCD  CAHILL  SMDAY         -   260   116   150   145   253   125   208    63   201   197     -     -     -     -     - G
H  UCD  CAHILL  TTLF        131   365   140   284   150   275   117   208    58   220   187   191   162   163   140   168 H
I  UCD  CAHILL  SFU          93   450   144   296   169   372   108   243    91   196   270   208   134   161   173   193 I
J  FSU  HUDSON  LS .2         -     -     -   150   139   222   120   140    81   310   281   197   225   174   183   194 J
K  FSU  HUDSON  LS .4         -     -     -   222   181   287   160   221    84   311   249   171   182   153   187   196 K

Z MEAN(ALL SAMPLERS)        160   489   190   279   202   370   144   230    65   293   266   245   170   248   177   248   236   59
   STANDARD DEVIATION        37   126    55    77    55    95    34    55    19    60    47    60    33    94    34    71

X MEAN(D,M,L,G,I,K)         155   486   177   281   201   366   148   224    72   273   272   249   167   234   172   244
   STANDARD DEVIATION        43   156    55    86    52    98    44    18    20    69    53    66    37    97    24    68

RATIO TO Z         PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A    •1.00 •0.99     - •1.00  0.90     -  0.79     -  0.70     -     - •1.01  0.73     -  0.78  0.83 D 0.87 0.12 14
M  EPA  DZUBAY   TF-M     1.10  1.41  1.15  1.39  1.38  1.32  1.57     -  1.44  1.07  1.18  1.12  1.23  1.06     -  1.11 M 1.25 0.16 13
N  EPA  DZUBAY   TF-P     1.08  1.08 •1.00  1.11     -  1.14  1.14  1.30  0.79 •1.05  0.94 •0.98  0.94  0.95  1.37  0.89 N 1.05 0.15 14
R  EPA  DZUBAY  MDS-S     0.90 •0.98  1.05 •1.04  0.93  1.11  0.84  1.27  0.56  1.07 •1.02 •0.95  0.79  0.88  0.73  0.89 R 0.94 0.17 16
C  LBL  LOO     DICOT        -     -     -  1.24  1.25  1.14 •0.97     -  0.82  1.12  1.17  1.40 •1.06  1.39 •1.05  1.42 C 1.17 0.18 16
L  LBL  LOO     DICOT     1.20  1.12  1.20  1.26  1.25  1.16 •1.09     -  0.87  1.17  1.24  1.41 •1.11  1.44 •1.08  1.41 L 1.20 0.15 12
S  LBL  LOO     DICOT     1.32  1.22  1.49     -  1.43  1.31  1.22     - •0.98  1.29     -     -     -  1.66  1.13  1.41 S 1.31 0.19 14
G  UCD  CAHILL  SMDAY        -  0.53  0.61  0.54  0.72  0.68  0.87  0.90 •0.98  0.69  0.74     -     -     -     -     - G 0.73 0.15 21
H  UCD  CAHILL  TTLF      0.82  0.75  0.74 •1.02  0.74  0.74  0.81 •0.90 •0.90  0.75  0.70  0.78 •0.95  0.66  0.79  0.68 H 0.80 0.10 13
I  UCD  CAHILL  SFU       0.58 •0.92  0.76 •1.06  0.84 •1.01  0.75 •1.06  1.41  0.67 •1.02 •0.85  0.79  0.65 •0.98  0.78 I 0.88 0.21 23
J  FSU  HUDSON  LS .2        -     -     -  0.54  0.69  0.60  0.84  0.61 •1.26 •1.06 •1.06  0.81  1.33  0.70 •1.04  0.78 J 0.87 0.26 29
K  FSU  HUDSON  LS .4        -     -     -  0.80 •0.90  0.78 •1.11 •0.96 •1.30 •1.06 •0.94  0.70 •1.07  0.62 •1.06  0.79 K 0.93 0.19 21

  MEAN(ALL SAMPLERS)      1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION     0.23  0.26  0.29  0.28  0.27  0.26  0.24  0.24  0.29  0.20  0.18  0.25  0.20  0.38  0.19  0.29    0.25

REGRESSION VS Z         INTERCEPT    ERROR     SLOPE     ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A     -33.103   13.028     1.060     0.054    18.230     0.990
M  EPA  DZUBAY   TF-M     -28.036   27.093     1.366     0.104    38.819     0.967
N  EPA  DZUBAY   TF-P      -7.243   20.711     1.092     0.081    30.322     0.966
R  EPA  DZUBAY  MDS-S     -34.406   18.668     1.121     0.073    27.782     0.971
C  LBL  LOO     DICOT     -24.582   29.734     1.312     0.125    33.028     0.958
L  LBL  LOO     DICOT       8.847   20.962     1.182     0.082    31.008     0.970
S  LBL  LOO     DICOT      14.322   27.043     1.271     0.104    38.339     0.971
G  UCD  CAHILL  SMDAY      49.831   21.562     0.483     0.078    27.687     0.910
H  UCD  CAHILL  TTLF       15.275   16.411     0.719     0.065    24.423     0.948
I  UCD  CAHILL  SFU       -18.581   25.419     0.953     0.100    37.828     0.931
J  FSU  HUDSON  LS .2      67.098   46.281     0.526     0.195    51.543     0.631
K  FSU  HUDSON  LS .4      52.984   30.185     0.652     0.127    33.617     0.840
```

```
1                   INTERCOMPARISON STUDY OF SMALL BR  ;  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD

D  EPA  DZUBAY  MDS-A     107   421   145   212   122     -    60   195    26   228   228   199    78     -    85   165 D
M  EPA  DZUBAY   TF-M     152   533   179   329   227   386   188     -    85   264   285   236   167   219   140   234 M
N  EPA  DZUBAY   TF-P     155   462   149   258   192   329   128   238    43   254   218   188   116   191   188   176 N
R  EPA  DZUBAY  MDS-S     105   429   151   239   128   317    71   231    22   266   203   198    80   172    75   174 R
C  LBL  LOO     DICOT     119     -     -   251   166   268    74     -    33   249   197   262   101   263   111   256 C
L  LBL  LOO     DICOT     125   452   156   254   164   267    79     -    35   256   216   261   104   269   112   258 L
S  LBL  LOO     DICOT     133   507   194     -   188   326    88     -    39   287     -     -     -   318   117   254 S
G  UCD  CAHILL  SMDAY     103   249    97   150   101   232   105   208    63   189   169     -     -     -     -     - G
I  UCD  CAHILL  SFU        72   347   120   242   133   274    61   164    55   146   179   138    92   103   135   148 I

Z MEAN(ALL SAMPLERS)      119   425   149   242   158   300    95   207    45   238   212   212   105   219   120   208     191   47
   STANDARD DEVIATION      26    91    31    50    40    49    41    30    20    44    36    45    30    72    35    47

X MEAN(D,M,L,G,I)         112   400   139   237   149   290    99   189    53   217   215   209   110   197   118   201
   STANDARD DEVIATION      29   108    32    65    49    67    53    23    23    49    46    53    39    85    25    53

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD CV

D  EPA  DZUBAY  MDS-A   0.90 •0.99 •0.97  0.88  0.77     -  0.63  0.94  0.58 •0.96  1.08  0.94  C.74     -  0.71  0.79 D 0.85 0.15 17
M  EPA  DZUBAY   TF-M   1.28  1.25  1.20  1.36  1.44  1.29  1.98     -  1.91  1.11  1.35  1.12  1.58 •1.00  1.16  1.12 M 1.34 0.28 21
N  EPA  DZUBAY   TF-P   1.30  1.09 •1.00  1.07  1.22  1.10  1.35  1.15 •0.97  1.07 •1.03  0.89  1.10  0.87  1.56  0.85 N 1.10 0.19 17
R  EPA  DZUBAY  MDS-S   0.88 •1.01 •1.01 •0.99  0.81  1.06  0.75  1.12  0.49  1.12 •0.96  0.94  0.76  0.78  0.62  0.84 R 0.88 0.18 20
C  LBL  LOO     DICOT  •1.00     -     - •1.04 •1.05  0.89  0.78     -  0.74 •1.05 •0.93  1.24 •0.96  1.20 •0.92  1.23 C 1.00 0.16 16
L  LBL  LOO     DICOT  •1.05 •1.06 •1.05 •1.05 •1.04  0.89  0.83     -  0.79 •1.08 •1.02  1.23 •0.99  1.23 •0.93  1.24 L 1.03 0.14 13
S  LBL  LOO     DICOT   1.12  1.19  1.30     -  1.19 •1.09 •0.93     -  0.88  1.21     -     -     -  1.45 •0.97  1.22 S 1.14 0.17 15
G  UCD  CAHILL  SMDAY   0.87  0.59  0.65  0.62  0.64  0.77 •1.11 •1.00  1.41  0.80  0.80     -     -     -     -     - G 0.84 0.25 30
I  UCD  CAHILL  SFU     0.61  0.82  0.81 •1.00 •0.84 •0.91  0.64  0.79 •1.23  0.61 •0.85  0.65 •0.87  0.47 •1.12  0.71 I 0.81 0.20 25

  MEAN(ALL SAMPLERS)    1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00    1.00
   STANDARD DEVIATION   0.22  0.21  0.21  0.21  0.26  0.16  0.43  0.14  0.45  0.19  0.17  0.21  0.29  0.33  0.29  0.22    0.25

REGRESSION VS Z          INTERCEPT     ERROR     SLOPE     ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A     -29.844      9.709     1.061     0.048    16.011     0.988
M  EPA  DZUBAY   TF-M      27.000     18.720     1.131     0.089    31.364     0.962
N  EPA  DZUBAY   TF-P      14.661     16.71      0.999     0.079    28.059     0.958
R  EPA  DZUBAY  MDS-S     -34.747     12.482     1.119     0.059    20.958     0.981
C  LBL  LOO     DICOT     -10.416     19.891     1.094     0.106    26.794     0.952
L  LBL  LOO     DICOT      -5.227     14.444     1.084     0.069    24.201     0.975
S  LBL  LOO     DICOT     -10.052     16.249     1.234     0.076    25.551     0.983
G  UCD  CAHILL  SMDAY      44.070     18.296     0.540     0.082    27.261     0.910
I  UCD  CAHILL  SFU        -1.398     19.392     0.796     0.092    32.559     0.918
```

```
1                   INTERCOMPARISON STUDY OF LARGE BR  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS         PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG    SD

D  EPA  DZUBAY  MDS-A       52    63     -    67    59     -    54     -    19     -     -    47    45     -    53    42 D
M  EPA  DZUBAY   TF-M       24    58    39    58    51   103    38     -     8    50    29    38    42    44     -    41 M
N  EPA  DZUBAY   TF-P       17    65    42    52     -    92    36    62     8    54    32    52    44    44    54    46 N
R  EPA  DZUBAY  MDS-S       39    50    48    52    59    93    49    61    14    48    68    35    54    46    53    48 R
C  LBL  LOO     DICOT        -     -     -    95    87   154    65     -    20    80   113    81    79    82    74    96 C
L  LBL  LOO     DICOT       67    94    73    99    88   163    78     -    22    88   115    84    84    89    79    93 L
S  LBL  LOO     DICOT       77    90    90     -   101   170    87     -    24    90     -     -     -    95    82    96 S
G  UCD  CAHILL  SMDAY        -    11    19     -    44    21    20     -     -    13    28     -     -     -     -     - G
I  UCD  CAHILL  SFU         21   103    24    54    36    98    47    79    36    50    91    70    42    58    38    45 I

Z MEAN(WITHOUT G)           42    75    53    68    69   125    57    67    19    66    75    58    56    65    62    63       64    23
   STANDARD DEVIATION       24    21    24    20    24    36    18    10     9    19    38    20    18    23    17    26

X MEAN(D,M,L,I)             41    80    45    70    59   121    54    79    21    63    78    60    53    64    57    55
   STANDARD DEVIATION       22    22    25    20    22    36    17     0    12    22    44    21    21    23    21    25

RATIO TO Z      PERIOD       1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD CV

D  EPA  DZUBAY  MDS-A     1.23  0.84     - •0.98  0.86     - •0.95     - •1.01     -     -  0.81  0.81     -  0.86  0.66 D 0.90 0.15 17
M  EPA  DZUBAY   TF-M     0.57  0.78  0.74  0.85  0.74  0.83  0.67     -  0.42  0.76  0.39  0.65  0.75  0.67     -  0.65 M 0.68 0.14 20
N  EPA  DZUBAY   TF-P     0.40  0.87  0.80  0.76     -  0.74  0.63  0.92  0.42  0.82  0.43  0.89  0.79  0.67  0.87  0.73 N 0.72 0.17 24
R  EPA  DZUBAY  MDS-S     0.92  0.67  0.91  0.76  0.86  0.75  0.86  0.91  0.74  0.73  0.91  0.60 •0.97  0.70  0.86  0.76 R 0.81 0.11 13
C  LBL  LOO     DICOT        -     -     -  1.39  1.27  1.24  1.15     - •1.06  1.22  1.51  1.39  1.42  1.25  1.20  1.52 C 1.30 0.14 11
L  LBL  LOO     DICOT     1.58  1.26  1.39  1.45  1.28  1.31  1.37     -  1.17  1.34  1.54  1.45  1.51  1.36  1.28  1.47 L 1.38 0.12  8
S  LBL  LOO     DICOT     1.82  1.20  1.71     -  1.47  1.36  1.53     -  1.27  1.37     -     -     -  1.45  1.33  1.52 S 1.46 0.18 13
G  UCD  CAHILL  SMDAY        -  0.15  0.36     -  0.64  0.17  0.35     -     -  0.20  0.38     -     -     -     -     - G 0.32 0.17 53
I  UCD  CAHILL  SFU       0.50 •1.38  0.46 •0.79  0.52 •0.79 •0.83 •1.17  1.91 •0.76 •1.22 •1.20 •0.75 •0.89  0.61  0.71 I 0.91 0.38 42

 MEAN(WITHOUT G)          1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION     0.56  0.28  0.46  0.30  0.34  0.29  0.33  0.15  0.49  0.29  0.51  0.35  0.33  0.35  0.27  0.42   0.36

REGRESSION VS Z         INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A       9.603     9.256      0.712      0.157     7.554      0.848
M  EPA  DZUBAY   TF-M     -10.999     6.882      0.873      0.102     8.402      0.927
N  EPA  DZUBAY   TF-P      -3.829     8.005      0.797      0.120     9.830      0.879
R  EPA  DZUBAY  MDS-S       5.569     5.372      0.714      0.080     6.598      0.922
C  LBL  LOO     DICOT       2.343     7.898      1.276      0.115     8.895      0.962
L  LBL  LOO     DICOT       5.910     5.333      1.289      0.080     6.546      0.976
S  LBL  LOO     DICOT      11.276     7.850      1.263      0.116     9.352      0.964
G  UCD  CAHILL  SMDAY       0.        0.         0.         0.        0.         0.
I  UCD  CAHILL  SFU         3.377    15.643      0.822      0.234    19.213      0.685
```

```
1                   INTERCOMPARISON STUDY OF TOTAL PB  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS          PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY   MDS-A    845   792     -  1153   995     -   781     -   325   812  1194  1051   886     -   789   856 D
M  EPA  DZUBAY    TF-M    955   987   919  1320  1160  1768   849     -   275  1001  1324  1021  1001  1128   788   919 M
N  EPA  DZUBAY    TF-P    878   902   878  1219  1081  1600   846  1358   274   940  1192  1056  1032  1177   882   913 N
R  EPA  DZUBAY   MDS-S    745   722   815  1031   958  1423   696  1187   240   808  1148  1000   847   980   783   810 R
C  LBL  LOO      DICOT      -     -     -  1473  1275  1891   895     -   318  1060  1597  1309  1207  1482   999  1094 C
L  LBL  LOO      DICOT   1093  1065  1127  1477  1258  1881   937     -   329  1078  1599  1299  1203  1538  1020  1117 L
S  LBL  LOO      DICOT   1131  1079  1203     -  1333  1909   991     -   331  1060     -     -     -  1534  1057  1122 S
G  UCD  CAHILL   SMDAY      -   665   689  1066  1010  1257   586  1227   263   751  1023     -     -     -     -     - G
H  UCD  CAHILL   TTLF     753   770   835  1070   989  1312   638  1134   276   754  1010   972   828   899   691   830 H
I  UCD  CAHILL   SFU      686   749   763  1060   984  1345   780  1356   252   862  1333  1216  1044  1298   835   870 I
P  EPA  RODES    HIVOL   1000  1220  1070  1370  1230  1850   910  1370   310  1010  1540  1190  1310  1280  1080  1040 P
J  FSU  HUDSON   LS .2      -     -     -  1308  1145  1707  1062  1303  -545   997  1942  1320  1524  1408  1248  1030 J
K  FSU  HUDSON   LS .4      -     -     -  1698  1310  1946  1090  1422  -500   950  1890  1353  1509  1317  1243   981 K

Z MEAN(ALL SAMPLERS)      898   895   922  1270  1133  1657   851  1295   326   929  1399  1162  1126  1276   951   965   1066  182
   STANDARD DEVIATION     158   185   174   209   138   259   154   101    93   119   314   145   246   214   185   114

X MEAN(D,M,L,G,I,P,K)     916   913   914  1306  1135  1675   848  1344   322   923  1415  1188  1159  1312   959   964
   STANDARD DEV.ATION     156   213   189   234   137   296   157    83    84   118   287   132   228   147   186   102

RATIO TO Z       PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY   MDS-A   0.94  0.89     -  0.91  0.88     -  0.92     - •1.00  0.87  0.85  0.90  0.79     -  0.83  0.89 D 0.89 0.05  6
M  EPA  DZUBAY    TF-M   1.06  1.10 •1.00 •1.04 •1.02  1.07 •1.00     -  0.85  1.08  0.95  0.88  0.89  0.88  0.83  0.95 M 0.97 0.09  9
N  EPA  DZUBAY    TF-P  •0.98 •1.01  0.95 •0.96 •0.95 •0.97 •0.99 •1.05  0.84 •1.01  0.85  0.91  0.92  0.92  0.93  0.95 N 0.95 0.06  6
R  EPA  DZUBAY   MDS-S   0.83  0.81  0.88  0.81  0.85  0.86  0.82  0.92  0.74  0.87  0.82  0.86  0.75  0.77  0.82  0.84 R 0.83 0.05  6
C  LBL  LOO      DICOT      -     -     -  1.15  1.13  1.14 •1.05     - •0.98  1.14  1.14  1.13 •1.07  1.16 •1.05  1.13 C 1.11 0.06  5
L  LBL  LOO      DICOT   1.22  1.19  1.22  1.16 •1.11  1.14 •1.10     - •1.01  1.16  1.14  1.12 •1.07  1.21 •1.07  1.16 L 1.14 0.06  5
S  LBL  LOO      DICOT   1.26  1.21  1.30     -  1.18  1.15  1.17     - •1.02  1.14     -     -     -  1.20 •1.11  1.16 S 1.17 0.08  6
G  UCD  CAHILL   SMDAY      -  0.74  0.75  0.84  0.89  0.76  0.69 •0.95  0.81  0.81  0.73     -     -     -     -     - G 0.80 0.08 10
H  UCD  CAHILL   TTLF    0.84  0.86 •0.91  0.84 •0.87  0.79  0.75 •0.88  0.85  0.81  0.72  0.84  0.74  0.70  0.73  0.86 H 0.81 0.06  8
I  UCD  CAHILL   SFU     0.76  0.84  0.83  0.83  0.87  0.81 •0.92 •1.05  0.77 •0.93 •0.95 •1.05 •0.93 •1.02 •0.88 •0.90 I 0.90 0.09 10
P  EPA  RODES    HIVOL   1.11  1.36  1.16  1.08  1.09  1.12  1.07  1.06 •0.95  1.09  1.10 •1.02  1.16 •1.00  1.14  1.08 P 1.10 0.09  8
J  FSU  HUDSON   LS .2      -     -     - •1.03 •1.01 •1.03  1.25 •1.01  1.67 •1.07  1.39  1.14  1.35  1.10  1.31 •1.07 J 1.19 0.20 17
K  FSU  HUDSON   LS .4      -     -     -  1.34 •1.16  1.17  1.28 •1.10  1.53 •1.02  1.35  1.16  1.34 •1.03  1.31 •1.02 K 1.22 0.16 13

  MEAN(ALL SAMPLERS)     1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION    0.18  0.21  0.19  0.16  0.12  0.16  0.18  0.08  0.28  0.13  0.22  0.13  0.22  0.17  0.19  0.12   0.17

REGRESSION VS Z          INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY   MDS-A      60.151    50.577      0.819      0.049    44.073      0.982
M  EPA  DZUBAY    TF-M     -40.391    92.239      1.016      0.085    95.489      0.958
N  EPA  DZUBAY    TF-P      11.725    57.629      0.940      0.052    60.184      0.979
R  EPA  DZUBAY   MDS-S     -32.508    47.975      0.863      0.043    50.102      0.983
C  LBL  LOO      DICOT     -93.006    36.482      1.204      0.032    35.219      0.996
L  LBL  LOO      DICOT     -15.199    50.656      1.158      0.046    52.440      0.990
S  LBL  LOO      DICOT      -2.339    59.064      1.182      0.057    58.397      0.990
G  UCD  CAHILL   SMDAY     -19.288   100.046      0.818      0.089    98.419      0.956
H  UCD  CAHILL   TTLF       56.861    69.544      0.753      0.063    72.627      0.954
I  UCD  CAHILL   SFU       -57.364    97.227      0.959      0.088   101.538      0.946
P  EPA  RODES    HIVOL      34.563    78.906      1.068      0.071    82.404      0.970
J  FSU  HUDSON   LS .2     215.061   174.459      0.958      0.152   169.203      0.885
K  FSU  HUDSON   LS .4      52.681   155.912      1.152      0.136   151.215      0.931
```

```
1                  INTERCOMPARISON STUDY OF SMALL PB  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.

RESULTS        PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD

D  EPA  DZUBAY  MDS-A   677   671   713   955   801     -   633  1045   249   663   975   899   755     -   637   722 D
M  EPA  DZUBAY   TF-M   812   761   769  1099   898  1435   685     -   229   819  1167   869   769   949   673   759 M
N  EPA  DZUBAY   TF-P   792   730   698  1013   884  1310   686  1122   224   741  1050   876   831   989   689   728 N
R  EPA  DZUBAY  MDS-S   615   617   660   887   769  1170   544  1012   199   656   914   828   670   837   606   660 R
C  LBL  LOO     DICOT   747     -     -  1132   899  1377   638     -   245   782  1134  1022   890  1177   721   821 C
L  LBL  LOO     DICOT   742   801   809  1115   884  1331   651     -   244   762  1127   995   878  1197   715   825 L
S  LBL  LOO     DICOT   733   800   798     -   893  1341   662     -   236   755  1160  1005     -  1193   735   816 S
G  UCD  CAHILL  SMDAY   588   552   619   946   829  1167   500  1105   218   676   898     -     -     -     -     - G
I  UCD  CAHILL  SFU     582   596   597   853   867  1036   552  1112   207   697  1039  1016   819  1059   634   677 I
O  EPA  RODES   DICOT   730   710   650   670   660  1410   600   890   260   650   890  1190  1100   970   730   880 O

Z MEAN(ALL SAMPLERS)    702   693   701   963   838  1286   615  1048   231   720  1035   967   839  1046   682   765    821   89
   STANDARD DEVIATION    82    90    77   149    77   133    64    88    19    59   110   111   127   133    47    75

X MEAN(D,M,L,G,I,O)     689   682   693   940   823  1276   604  1038   235   711  1016   994   864  1044   678   773
   STANDARD DEVIATION    91    96    85   165    88   170    68   103    20    66   116   126   140   113    44    81

RATIO TO Z     PERIOD     1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    AVG   SD CV

D  EPA  DZUBAY  MDS-A •0.97 •0.97 •1.02 •0.99 •0.96     - •1.03 •1.00  1.08  0.92  0.94  0.93  0.90     -  0.93  0.94 D 0.97 0.05  5
M  EPA  DZUBAY   TF-M  1.16  1.10  1.10  1.14  1.07  1.12  1.11     - •0.99  1.14  1.13  0.90  0.92  0.91 •0.99 •0.99 M 1.05 0.09  9
N  EPA  DZUBAY   TF-P  1.13 •1.05 •1.00 •1.05 •1.05 •1.02  1.12  1.07 •0.97 •1.03 •1.01  0.91 •0.99  0.95 •1.01 •0.95 N 1.02 0.06  6
R  EPA  DZUBAY  MDS-S  0.88  0.89  0.94  0.92  0.92  0.91  0.88 •0.97  0.86  0.91  0.88  0.86  0.80  0.80  0.89  0.86 R 0.89 0.05  5
C  LBL  LOO     DICOT •1.06     -     -  1.18 •1.07 •1.07 •1.04     - •1.06 •1.09 •1.10 •1.06 •1.06  1.13 •1.06 •1.07 C 1.08 0.04  3
L  LBL  LOO     DICOT •1.06  1.16  1.15  1.16 •1.05 •1.04 •1.06     - •1.06 •1.06 •1.09 •1.03 •1.05  1.14 •1.05 •1.08 L 1.08 0.05  4
S  LBL  LOO     DICOT •1.04  1.15  1.14     - •1.07 •1.04 •1.08     - •1.02 •1.05  1.12 •1.04     -  1.14 •1.08 •1.07 S 1.08 0.04  4
G  UCD  CAHILL  SMDAY  0.84  0.80  0.88 •0.98 •0.99 •0.91  0.81 •1.06 •0.94 •0.94  0.87     -     -     -     -     - G 0.91 0.08  9
I  UCD  CAHILL  SFU    0.83  0.86  0.85 •0.89 •1.03  0.81 •0.90 •1.06 •0.90 •0.97 •1.00 •1.05 •0.98 •1.01 •0.93 •0.88 I 0.93 0.08  9
O  EPA  RODES   DICOT •1.04 •1.02 •0.93  0.70  0.79 •1.10 •0.98  0.85 •1.13 •0.90  0.86  1.23  1.31 •0.93 •1.07 •1.15 O 1.00 0.16 16

  MEAN(ALL SAMPLERS)   1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00   1.00
   STANDARD DEVIATION  0.12  0.13  0.11  0.15  0.09  0.10  0.10  0.08  0.08  0.08  0.11  0.12  0.15  0.13  0.07  0.10   0.11

REGRESSION VS Z         INTERCEPT     ERROR     SLOPE     ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A      27.910    31.830     0.926     0.040    30.207      0.989
M  EPA  DZUBAY   TF-M       2.939    79.233     1.047     0.094    85.506      0.951
N  EPA  DZUBAY   TF-P      27.330    45.873     0.984     0.054    50.263      0.980
R  EPA  DZUBAY  MDS-S      -9.111    39.453     0.898     0.046    43.229      0.982
C  LBL  LOO     DICOT     -27.266    31.487     1.117     0.037    32.645      0.994
L  LBL  LOO     DICOT       8.839    39.518     1.071     0.047    42.647      0.988
S  LBL  LOO     DICOT       3.015    34.855     1.078     0.042    37.410      0.992
G  UCD  CAHILL  SMDAY     -56.059    65.942     0.987     0.078    68.687      0.973
I  UCD  CAHILL  SFU       -24.562    74.333     0.970     0.087    81.448      0.948
O  EPA  RODES   DICOT      41.231   138.748     0.939     0.163   152.028      0.839
```

```
1
                        INTERCOMPARISON STUDY OF LARGE PB  :  NANOGRAMS/CUBIC METER; PERIODS 1-16, MAY 11-18 1977.
RESULTS            PERIOD    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16     AVG   SD
D  EPA  DZUBAY  MDS-A      168   121     -   198   194     -   148     -    76   149   219   151   131     -   152   134 D
M  EPA  DZUBAY   TF-M      143   226   150   221   262   333   164     -    47   182   157   152   232   179   115   160 M
N  EPA  DZUBAY   TF-P       85   172   180   216   197   290   160   236    50   199   142   180   201   188   193   185 N
R  EPA  DZUBAY  MDS-S      130   105   155   144   189   253   152   175    41   152   234   172   177   143   177   150 R
C  LBL  LOO     DICOT        -     -     -   341   376   514   257     -    73   278   463   287   317   305   278   273 C
L  LBL  LOO     DICOT      351   264   318   362   374   550   286     -    85   316   472   304   325   341   305   272 L
S  LBL  LOO     DICOT      338   279   405     -   440   568   329     -    95   305     -     -     -   341   322   306 S
G  UCD  CAHILL  SMDAY        -   113    70   120   181    90    86   122    45    75   125     -     -     -     -     - G
I  UCD  CAHILL  SFU        104   153   166   207   117   309   228   244    45   165   294   200   225   239   201   193 I

Z MEAN(ALL SAMPLERS)       197   179   206   226   259   363   201   194    62   202   263   207   230   248   218   209     217   86
   STANDARD DEVIATION      125    69   114    85   111   167    78    57    20    81   137    63    71    82    75    65

X MEAN(D,M,L,G,I)          192   175   176   222   226   321   182   183    60   177   253   202   228   253   193   190
   STANDARD DEVIATION      110    67   104    88    98   188    77    86    19    88   138    72    79    82    82    60
RATIO TO Z         PERIOD    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16      AVG   SD CV

D  EPA  DZUBAY  MDS-A     0.85  0.68     -  0.88  0.75     -  0.74     -  1.23  0.74  0.83  0.73  0.57     -  0.70  0.64 D 0.78 0.17 21
M  EPA  DZUBAY   TF-M     0.73  1.26  0.73 •0.98 •1.01  0.92  0.82     -  0.76  0.90  0.60  0.74 •1.01  0.72  0.53  0.77 M 0.83 0.19 22
N  EPA  DZUBAY   TF-P     0.43  0.96  0.87 •0.96  0.76  0.80  0.80  1.22  0.81 •0.98  0.54  0.87  0.88  0.76  0.89  0.89 N 0.84 0.18 21
R  EPA  DZUBAY  MDS-S     0.56  0.59  0.75  0.64  0.73  0.70  0.76  0.90  0.66  0.75  0.89  0.83  0.77  0.58  0.81  0.72 R 0.73 0.10 13
C  LBL  LOO     DICOT        -     -     -  1.51  1.45  1.41  1.28     -  1.18  1.37  1.76  1.39  1.38  1.23  1.28  1.31 C 1.38 0.15 11
L  LBL  LOO     DICOT     1.78  1.47  1.54  1.60  1.45  1.51  1.42     -  1.37  1.56  1.79  1.47  1.42  1.38  1.40  1.30 L 1.50 0.14  9
S  LBL  LOO     DICOT     2.02  1.56  1.96     -  1.70  1.56  1.64     -  1.54  1.51     -     -     -  1.38  1.48  1.46 S 1.62 0.20 13
G  UCD  CAHILL  SMDAY        -  0.63  0.34  0.53  0.70  0.25  0.43  0.63  0.73  0.37  0.48     -     -     -     -     - G 0.51 0.16 32
I  UCD  CAHILL  SFU       0.53 •0.85 •0.81 •0.92  0.45 •0.85 •1.13 •1.26  0.73 •0.82 •1.12 •0.97 •0.98 •0.96 •0.92 •0.92 I 0.89 0.21 23

 MEAN(ALL SAMPLERS)       1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00     1.00
   STANDARD DEVIATION     0.63  0.39  0.56  0.38  0.43  0.46  0.39  0.29  0.33  0.40  0.52  0.31  0.31  0.33  0.35  0.31     0.40

REGRESSION VS Z          INTERCEPT     ERROR      SLOPE      ERROR  RMS.DEV. COR.COEFF.
D  EPA  DZUBAY  MDS-A       24.628    26.890      0.630      0.129    21.699    0.841
M  EPA  DZUBAY   TF-M       -8.439    40.698      0.871      0.180    41.515    0.802
N  EPA  DZUBAY   TF-P       30.375    36.759      0.689      0.164    37.995    0.747
R  EPA  DZUBAY  MDS-S        2.585    21.116      0.724      0.094    21.826    0.899
C  LBL  LOO     DICOT      -32.492    36.527      1.544      0.157    35.238    0.952
L  LBL  LOO     DICOT      -12.247    31.826      1.562      0.141    32.464    0.951
S  LBL  LOO     DICOT       18.713    44.570      1.528      0.199    44.783    0.931
G  UCD  CAHILL  SMDAY       53.937    35.883      0.226      0.158    35.977    0.452
I  UCD  CAHILL  SFU          9.199    45.466      0.849      0.203    46.995    0.746
```